

ME ndip *Sketching Office*
J. Castles

MEMOIRS OF THE GEOLOGICAL SURVEY.

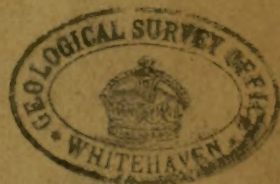
SPECIAL REPORTS ON THE MINERAL
RESOURCES OF GREAT BRITAIN.

NGI STORAGE

VOL. IX.—IRON ORES (*contd.*). SUNDRY UNBEDDED ORES
OF DURHAM, EAST CUMBERLAND, NORTH WALES,
DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT
AND SOMERSET, DEVON AND CORNWALL

By T. C. CANTRILL, B.Sc., R. L. SHERLOCK, D.Sc.,
AND HENRY DEWEY.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S
STATIONERY OFFICE.

By JAS. TRUSCOTT AND SON, LTD., CANNON STREET, E.C. 4.

And to be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C. 2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & Co., LTD., GRAFTON STREET, DUBLIN.

From any Agent for the sale of Ordnance Survey Maps, or through any Bookseller,
or from the Director-General, Ordnance Survey Office, Southampton.

1919.

Price 3s. 6d. Net.

GEOLOGICAL SURVEY OF ENGLAND AND WALES, AND MUSEUM OF PRACTICAL GEOLOGY.

(OFFICE: 28, JERMYN STREET, LONDON, S.W. 1.)

LIST OF PUBLICATIONS.

The publications include Maps, Memoirs, Museum Catalogues, Catalogue of Photographs, Guides, &c.

A complete list can be obtained from the Ordnance Survey Office, Southampton, price 6d. The Maps and Memoirs can be obtained from the Ordnance Survey, or from Agents. Museum Catalogues, Guides, &c., are sold at the Museum.

INDEX MAP OF THE BRITISH ISLES.

On the scale of 1-25th inch to the mile (1 to 1584000).

Price—Coloured, 2s., Uncoloured, 1s.

QUARTER-INCH MAP OF ENGLAND AND WALES (1 inch to the mile, or 1 to 253440).

Sheet.	Solid.	Drift.	Sheet.	Solid.	Drift.
	s. d.	s. d.		s. d.	s. d.
TITLE SHEET...	2	0	14. (ABERYSTWYTH, HEREFORD)...	2	6
1 with 2. (ALNWICK, BÉRWICK, &c.)...	2	6	15. (BIRMINGHAM, OXFORD)...	2	6
3. (CARLISLE AND ISLE OF MAN)...	2	6	16. (CAMBRIDGE, IPSWICH)...	2	6
4. (NEWCASTLE, STOCKTON, &c.)...	2	6	18. (BRISTOL, CARDIFF, &c.)...	2	6
5 with 6. (LANCASTER and ISLE OF MAN)...	2	6	19. (BATH, GUILDFORD, SOUTH-AMPTON)...	2	6
7. (MANCHESTER, LEEDS, &c.)...	2	6	20 with 24. (LONDON, DOVER, and BRIGHTON)...	2	6
8. (FLAMBORO' HEAD and GRIMSBY)...	2	0	21 with 25. (KALMOUTH with ISLES OF SCILLY)...	2	6
9 with 10. (HOLYHEAD, SHREWSBURY, &c.)...	2	6	22. (PLYMOUTH and LYME REGIS)...	2	6
11. (STAFFORD, DERBY, LINCOLN, &c.)...	2	6	23. (BOURNEMOUTH to SELSEY BILL)...	2	0
12. (LOUTH and YARMOUTH)...	2	6	INDEX to COLOURS and SYMBOLS...	2	6
13 with part of 17. (FISHGUARD, MILFORD)...	2	6			

ONE-INCH MAP, NEW SERIES (1 inch to the mile, or 1 to 63360) WITH ACCOMPANYING MEMOIRS.

These are published in either a "Solid" or a "Drift" Edition, or in both. The majority of them are accompanied by Explanatory Memoirs. New Series Sheets 1 to 73 correspond to the Quarter Sheets of the Old Series Map 91 to 110. Some of these are now coloured-printed, and are given in the table below; the rest are still issued as sheets of the Old Series Map.

Price of Map.					Price of Map.				
Solid. Drift. Memoir.					Solid. Drift. Memoir.				
s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
33. STOCKTON ...	5	3	1	6	298. SALISBURY ...	—	1	6	1
34. GUISBROUGH ...	5	3	1	6	299. WINCHESTER ...	—	1	6	1
35 and 44. SCALBY AND WHITBY ...	—	1	6	2	300. ALRESFORD ...	—	1	6	2
42. NORTHALLERTON ...	9	0	1	6	311. WELLINGTON and CHARD ...	—	1	6	1
43. EGTON ...	10	6	1	6	314. RINGWOOD ...	—	1	6	1
52. RIPON and THIRSK ...	9	9	1	6	315. SOUTHAMPTON ...	—	1	6	1
53. PICKERING ...	9	0	1	6	316. HAVANT ...	—	1	6	1
54. SCARBOROUGH ...	6	9	1	6	317. CHICHESTER ...	—	1	6	1
55. FLAMBOROUGH ...	1	6	1	6	325. EXETER ...	—	1	6	2
62. HARROGATE ...	8	3	1	6	326 and 340. SILEMOUTH and LYME REGIS ...	—	1	6	1
63. YORK ...	9	9	1	6	328. DORCHESTER ...	—	1	6	1
64. DRIFFIELD ...	4	6	1	6	329. BOURNEMOUTH ...	5	3	1	6
65. BRIDLINGTON ...	1	6	1	6	330. NEW FOREST (pts.) I. OF WIGHT (pts.) ...	7	6	1	6
71. SELBY ...	3	9	1	6	331. PORTSMOUTH and I. OF WIGHT (pt.) ...	5	3	1	6
72. BEVERLEY ...	5	3	1	6	332. BOGNOR ...	2	0	1	6
73. HORNSEA ...	—	1	6	—	333. WORTHING and ROTTINGDEAN ...	—	1	6	—
100. SHEFFIELD ...	—	1	6	with 112	334. NEWHAVEN and EASTBOURNE ...	—	1	6	0
110. MACCLESFIELD, CONGLETON ...	—	1	6	2	335. TREVOSE HEAD ...	—	1	6	2
112. CHESTERFIELD ...	—	1	6	3	336. CAMELFORD ...	—	1	6	—
113. OLLERTON ...	—	1	6	2	337. TAVISTOCK and LAUNCESTON ...	—	1	6	3
123. STOKE-UPON-TRENT ...	1	6	1	6	338. DARTMOOR ...	—	1	6	2
125. DERBY and WIRKSWORTH ...	—	1	6	3	339. NEWTON ABBOT ...	—	1	6	3
126. NEWARK and NOTTINGHAM ...	—	1	6	2	341. WEST FLEET ...	—	1	6	—
141. LOUGHBOROUGH and BURTON ...	—	1	6	2	342. PORTLAND and WEYMOUTH ...	—	1	6	10
142. MELTON MOWBRAY ...	—	1	6	2	343. SWANAGE ...	—	1	6	—
155. ATHERSTONE and CHARNWOOD ...	11	3	1	6	346. NEWQUAY ...	—	1	6	3
156. LEICESTER ...	8	3	1	6	347. BODMIN and ST. AUS-TELL ...	—	1	6	4
187. HUNTINGDON ...	—	6	0	—	348. PLYMOUTH and LISKEARD ...	—	1	6	1
203. BEDFORD ...	—	9	9	—	349. IVYBRIDGE ...	—	1	6	3
227. MILFORD ...	—	—	—	2	350. TORQUAY ...	—	1	6	2
228. HAVERFORDWEST ...	—	—	—	3	351 and 358. LAND'S END DISTRICT ...	—	2	6	2
229. CARMARTHEN ...	1	6	1	6	352. FALMOUTH and TRURO ...	—	1	6	7
230. AMMANFORD ...	1	6	1	6	353. MEVAGISSEY ...	—	1	6	1
231. MERTHYR TYDFIL ...	1	6	1	6	355. KINGSBRIDGE ...	—	1	6	1
232. ABERGAVENNY ...	1	6	1	6	356. START POINT ...	—	1	6	—
246. WEST GOWER ...	1	6	1	6	357 and 360. ISLES OF SCILLY ...	—	1	6	1
247. SWANSEA ...	1	6	1	6	359. LIZARD ...	—	1	6	5
248. PONTYPRIDD ...	1	6	1	6	LONDON (4 Sheets), each ISLE OF MAN (Sheets 36, 45, 46, 56 and 57) ...	11	0	2	6
249. NEWPORT (Mon.) ...	1	6	1	6	ISLE OF WIGHT (Special Sheet) ...	—	2	6	8
254. HENLEY-ON-THAMES ...	—	1	6	2	NOTTINGHAM (Special Sheet) ...	—	1	6	2
261-2. BRIDGEND ...	1	6	1	6	OXFORD (Special Sheet) ...	—	1	6	2
263. CARDIFF ...	1	6	1	6					
267. HUNGERFORD and NEWBURY ...	—	1	6	2					
268. READING ...	6	9	1	6					
269. WINDSOR ...	—	—	—	2					
282. DEVIZES ...	—	1	6	1					
283. ANDOVER ...	—	1	6	1					
284. BASINGSTOKE ...	—	1	6	2					
295. TAUNTON and BRIDGWATER ...	—	1	6	2					

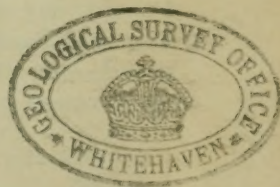
MEMOIRS OF THE GEOLOGICAL SURVEY.

SPECIAL REPORTS ON THE MINERAL RESOURCES OF GREAT BRITAIN.

VOL. IX.—IRON ORES (*contd.*). SUNDRY UNBEDDED ORES
OF DURHAM, EAST CUMBERLAND, NORTH WALES,
DERBYSHIRE, THE ISLE OF MAN, BRISTOL DISTRICT
AND SOMERSET, DEVON AND CORNWALL.

By T. C. CANTRILL, B.Sc., R. L. SHERLOCK, D.Sc.,
AND HENRY DEWEY.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HIS MAJESTY'S TREASURY.



LONDON:
PRINTED UNDER THE AUTHORITY OF HIS MAJESTY'S
STATIONERY OFFICE.
By JAS. TRUSCOTT AND SON, LTD., CANNON STREET, E.C. 4.

And to be purchased from
E. STANFORD, LTD., 12, 13 and 14, LONG ACRE, LONDON, W.C. 2;
W. & A. K. JOHNSTON, LTD., 2, ST. ANDREW SQUARE, EDINBURGH;
HODGES, FIGGIS & CO., LTD., GRAFTON STREET, DUBLIN.

From any Agent for the sale of Ordnance Survey Maps, or through any Bookseller,
or from the Director-General, Ordnance Survey Office, Southampton.

1919.

Price 3s. 6d. Net.

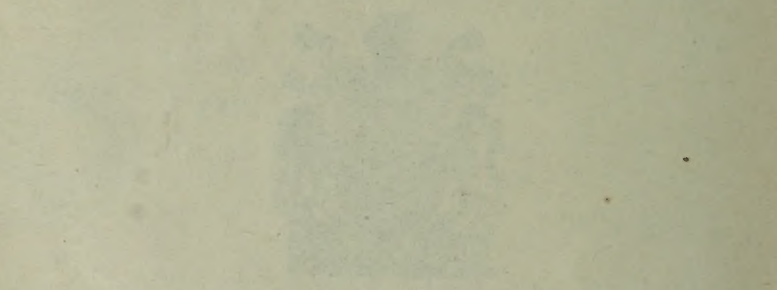
MEMOIRS OF THE GEOLOGICAL SURVEY

MINERAL REPORTS ON THE MINERAL
RESOURCES OF GREAT BRITAIN.

THE IRON ORES OF THE STRIDRY DISTRICTS OF
DUBLIN, EAST DUBLIN, NORTH DUBLIN,
DUBLIN, THE LEE OF DUBLIN, BRISTOL DISTRICT
AND SOMERSET, DEVON AND CORNWALL.

BY THE HON. HENRY DUNDAS, ESQ., M.P.
AND HENRY DUNDAS, ESQ.

LONDON: PRINTED BY J. JOHNSON, ST. PAUL'S CHURCH-YARD, 1825.



THE HON. HENRY DUNDAS, ESQ., M.P.
AND HENRY DUNDAS, ESQ.

LONDON: PRINTED BY J. JOHNSON, ST. PAUL'S CHURCH-YARD, 1825.



PREFACE

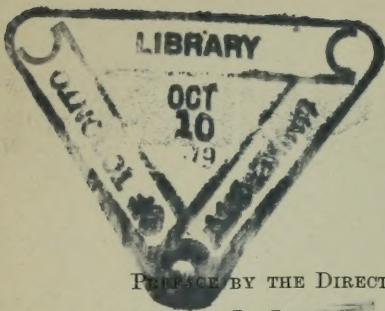
The initiation of a series of volumes descriptive of the Iron Ores of Great Britain is outlined in the Preface to the first of those volumes to be published, namely, that in which the hæmatites of the North-West of England are dealt with (Special Reports on the Mineral Resources of Great Britain, vol. viii).

The present volume, in continuation of the general subject, is devoted to an account of a number of unbedded ores, including limonites, spathic and magnetic ores, with some scattered hæmatites of small commercial importance. Some of the ores described have been worked for other purposes than the production of iron.

The majority of the mines described are inactive and some have been long abandoned. The information relating to these has been assembled from previous Memoirs of the Geological Survey and from other publications. Such field-work as was necessary for the investigation of mines now in operation, or the reopening of which appeared possible, was carried out in 1917. The mines of the County of Durham and of East Cumberland were visited by Dr. R. L. Sherlock, those of North Wales and Somerset by Mr. T. C. Cantrill and Dr. Sherlock, those of South Devon and Cornwall by Mr. H. Dewey. Each officer supplies an account of the mines visited by himself.

A. SIRAHAH,
Director.

Geological Survey Office,
28, Jermyn Street, London, S.W. 1,
18th December, 1918.



CONTENTS

	PAGE
PREFACE BY THE DIRECTOR	iii
CHAPTER I.—INTRODUCTION	1
„ II.—CO. DURHAM AND EAST CUMBERLAND.—WEARDALE, CO. DURHAM: General Account. Details of the Mines. TEESDALE. ALSTON DISTRICT, CUMBERLAND: General Account. Details of the Veins	4
„ III.—NORTH WALES, DERBYSHIRE, AND THE ISLE OF MAN.—NORTH WALES: General Account. Details of the Mines. DERBYSHIRE. THE ISLE OF MAN	15
„ IV.—BRISTOL DISTRICT, WEST SOMERSET AND NORTH DEVON.—BRISTOL DISTRICT: General Account. Details of the Mines. WEST SOMERSET AND NORTH DEVON: Minehead District, Brendon Hills, Eisen Hill, Exmoor District, North Molton District, Barnstaple District, Ilfracombe District	28
„ V.—SOUTH DEVON AND CORNWALL.—SOUTH DEVON: General Account. Details of the Mines. Other South Devon Mines. CORNWALL: General Account. Details of the Mines. Newquay District, Wadebridge and St. Austell District, Truro and Helston District. Smaller Mines ...	46
INDEX	81

ILLUSTRATIONS

	PAGE
FIG 1.—Map of Iron-mining District, Cwm, near Dyserth, Flintshire...	17
„ 2.—Map of Iron-mining District, Bodfari, Flintshire	20
„ 3.—Map of Iron-mining District, Abergele, Denbighshire	24
„ 4.—Map of Iron-mining District, Brendon Hills, Somerset... ..	32
„ 5.—Map of Iron-mining District, Bovey Tracey, Devon	51
„ 6.—Map of Sharkham Point, Brixham, Devon	53
„ 7.—Map of Iron-mining Districts: Newquay, Wadebridge and St. Austell Districts, Cornwall	57

IRON ORES:

SUNDRY UNBEDDED ORES

CHAPTER I

INTRODUCTION

This volume deals with some relatively unimportant sources of unbedded iron-ore, in various parts of England and Wales specified below. The ores occur as irregular bodies, pockets, flats, and veins. The table on page 3 shows the districts referred to, together with the outputs in tons for the three years preceding the war; for purposes of comparison the figures for Cumberland and Lancashire also are given.

In the Carboniferous and Devonian limestones the hæmatite forms flats, pockets, and vein-like masses; in the older Palæozoic rocks of the Isle of Man, and in the Coal Measures of the Bristol district (*i.e.*, South Gloucestershire and North Somerset), it occurs as true veins; in the Dolomitic Conglomerate (Trias) of the last-named district it is present as lenticular masses. In the Devonian Slates of West Somerset and North Devon, in the Carboniferous Limestone Series of Durham and East Cumberland, and in the Granite and Killas of South Devon and Cornwall, the spathic ore occurs in true veins, though at the surface it has generally changed into hæmatite and limonite. In South Devon and Cornwall the specular ores form true veins, and the magnetite occurs usually in lenticles associated with basic igneous rocks, from which it was probably derived by magmatic segregation.

The output of hæmatite from North Wales, Derbyshire, the Isle of Man, and North Somerset, always small, has practically ceased. Of the small amount of hæmatite raised before the war in South Devon, the greater part was used for paint; latterly it has been used also as a source of iron. Spathic vein-ore now takes a very small share in the supply of ironstone, and though once of importance in the Brendon Hills, Exmoor, and Weardale, it is now raised, in small quantities only, in Weardale and Cornwall. From Cornwall and from South Devon some magnetite is derived.

No precise estimate of the reserves of these ores is possible. In North Wales and North Somerset not more than a few thousand tons can be relied on. Future supplies from the Isle of Man are wholly speculative, and from Derbyshire are negligible. Of spathic ore there are no doubt considerable reserves in Durham, West Somerset, Devon, and Cornwall. The following table shows the reserves in tons so far as can be stated, together with those of Cumberland and Lancashire for comparison:—

Ore.	District.	Reserves more or less developed.	Probable additional Reserves.
Spathic ...	Durham and East Cumberland ...	—	250,000
Hæmatite ...	North Wales ...	—	A few thousand ?
	Derbyshire ...	—	?
	Isle of Man ...	—	None ?
	Bristol District ...	—	A few thousand ?
Spathic ...	West Somerset and North Devon ...	—	?
Hæmatite ...	Cornwall and South Devon ...	—	500,000
Spathic and Magnetite ...			
Hæmatite ...	Cumberland and Lan- cashire ...	45 million.	90 million.

That the reserves of hæmatite are sufficient sensibly to modify the estimates of British reserves is most improbable, but that some exist is certain. Having regard to all the circumstances, it appears necessary to frame an approximate estimate and, in doing so, to take into account the productiveness of the mines in the closing years of their activities. Accordingly, the estimates are founded on the assumption that, in the aggregate, the lodes contain a reserve of ore equal to the aggregate output of the last 10 years, or in some cases the last 20 years, of the mining operations. This basis, arbitrary though it is, leads to an estimate bearing some relation to the proved productiveness of past years.²

The hæmatite of North Wales, Derbyshire, North Somerset and South Devon has been formed by metasomatic replacement of limestone by the action of ferruginous solutions. Though in the majority of cases the replacement may be comparable in age and character with the replacement of limestone in West Cumberland and North Lancashire, this may not be true of the ore found in the Carboniferous Basement Beds of the Abergele district of North Wales. This ore is not associated with any visible sign of a former extension of the Trias, while, on the other hand, it is contained in a formation that resembles the Trias in the prevalence of iron and in its unconformable relation to all older rocks.

The hæmatite in the veins among the older Palæozoic rocks of the Isle of Man, and among the Coal Measures of the Bristol District, was perhaps formed by the alteration of calcite and dolomite veins by ferruginous waters derived from Triassic deposits.

The spathic vein-ore of West Somerset, Devon, and Cornwall consists in depth of chalybite; but near and at the surface this has been converted by hydration and oxidation into either limonite or hæmatite, in some cases manganiferous.

The spathic ore in the veins of Cornwall, Durham, and East Cumberland is in some cases associated with fluor-spar and galena, and it is probable that heated vapours and solutions played a part in its formation. At the surface it becomes converted into limonite.

¹ This includes the pisolitic bedded ores of North Wales described in 'Special Reports,' vol. xiii.

² 'Summary of Progress for 1917' (*Mem. Geol. Surv.*), 1918, p. 6.

District.	Country Rock.	Kind of Ore.	Output in 1911.	Output in 1912.	Output in 1913.	Remarks.
Durham Co. ...	Carboniferous Limestone Series	Spathic and limonite.	3,955 nil.	3,033 nil.	36 nil.	Carricks Mine.
East Cumberland	Carboniferous Limestone Series	...	2,333	1,793	657	Ty'n-y-caeau Mine.
North Wales	Carboniferous Limestone Series	Haematite	...	...	...	No output since 1878 or earlier.
Derbyshire ...	Carboniferous Limestone Series	Haematite	...	...	...	No output since 1881.
Isle of Man ...	Manx Slates (Cambrian ?)	Haematite and limonite.	...	...	...	No output since 1893.
Bristol District	Carboniferous Limestone Series, Measures, and Trias.	Haematite and limonite.	...	...	...	Exmoor Mine.
West Somerset	Devonian Slates	Spathic, with haematite and limonite.	200 nil.	400 nil.	850 nil.	No output since 1892.
North Devon	Devonian Slates	...	...	...	...
South Devon	Granite and killas ¹ and Devonian lime-stone	limonite. Magnetite, limonite, haematite (including specular) and spathic.	160 312	150 nil.	20 nil.	Brixham Mines.* Restormel Mine.* (* Haematite).
Cornwall ...	...	...	...	...	...
West Cumberland	Carboniferous Limestone Series and old Palaeozoic Rocks of Lake District	Haematite	1,273,557 439,475	1,207,971 360,446	1,360,924 406,155	Almost all from Carboniferous Limestone Series.
North Lancashire	...	...	...	...	...

¹ A local term for sedimentary rocks of any Palaeozoic age, as distinguished from granite and other igneous rocks.

CHAPTER II

CO. DURHAM AND EAST CUMBERLAND

By R. L. SHERLOCK

WEARDALE, CO. DURHAM

GENERAL ACCOUNT

Ironstone was worked in Weardale at least as early as the 12th century, when a lease of an iron mine at Rookhope was granted by the Bishop of Durham for making ploughs. The modern period of working, however, may be said to have begun some time between 1820 and 1840. About 1842 a furnace built at Stanhope, a short time before, was bought by Chas. Attwood, who afterwards formed the Weardale Iron Company. Development was rapid and the output of ore approached 100,000 tons per annum.

The first small furnace was erected at Stanhope Dene, but, to obviate the necessity of bringing in coal from a distance, furnaces were erected at Tow Law, where the company purchased collieries. As additional furnaces came into action the local supply of ironstone became insufficient, and about 1851 Cleveland ores were brought into the district, and in a short time entirely superseded the local ores.¹ It appears² that Weardale ores began to be worked again in 1861, and, according to the Home Office Returns, have been worked ever since, but on a very small scale. In 1917 the output for the whole of Weardale was about 300 tons weekly.

Weardale ores have borne a good reputation from early days. R. Meade³ records that the 'rider' ore from the lead veins bears a high name for bar iron and has been found well adapted for the manufacture of the finer kinds of tough steel used for chains, ploughs, and other small articles that use up a small quantity of ore.

The ore occurs in the form of iron carbonate ('spathic') and limonite ('brown hæmatite'). The percentage of iron varies from 30 to as much as 50 or 60, but the average proportion in 1917, as given in the Home Office Returns, was 37 per cent. The following analyses (p. 5) show their average composition:—

¹ I. L. Bell, 'On the Manufacture of Iron in connexion with the Northumberland and Durham Coalfield,' *Rep. Brit. Assoc.* for 1863 (1864), p. 740.

² R. Meade, 'Coal and Iron Industries of the United Kingdom,' Lond., 1882, p. 334.

³ *Ibid.*

Analyses of Weardale Iron-ores.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Peroxide of iron ...	49.50	—	0.81	71.11	—	—	—	—
Protoxide of iron ...	10.77	49.47 ¹	49.77	—	—	—	—	—
Protoxide of manganese ...	3.06	2.42	1.93	6.60	—	—	—	—
Alumina ...	0.43	trace.	—	0.40	—	—	—	—
Lime ...	5.68	3.47	3.96	0.56	—	—	—	—
Magnesia ...	1.20	3.15	2.83	1.90	—	—	—	—
Silica ...	0.29	1.20 ²	—	—	8.59	9.25	9.90	11.23
Carbonic acid ...	14.49	37.71 ³	37.20	0.13	—	—	—	—
Phosphoric acid ...	0.01	trace.	trace.	0.22	—	—	—	—
Phosphorus ...	—	—	—	—	0.014	0.15 ⁴	0.023	0.026
Sulphuric acid ...	trace.	trace.	—	—	—	—	—	—
Sulphur ...	—	—	0.04	—	—	—	—	—
Bisulphide of iron ...	0.03	0.08	—	—	—	—	—	—
Water, hygroscopic ...	1.81	—	—	—	—	—	—	—
Water in combination..	6.63	—	—	—	—	—	—	—
Water ...	—	—	0.30	12.40	7.08	—	11.95	—
Organic matter ...	trace.	trace.	—	—	—	—	—	—
Calcium carbonate ...	—	—	—	—	5.85	6.30	0.44	0.50
Insoluble residue ...	6.90	3.77 ⁴	3.12	6.32 ⁶	—	—	—	—
	100.80	101.27	99.96	99.64				
Insoluble residue :—								
Silica ...	6.35	3.73	—	—	—	—	—	—
Alumina ...	0.41	0.06 ⁵	—	—	—	—	—	—
Peroxide of iron ...	0.07	—	—	—	—	—	—	—
Lime ...	0.01	—	—	—	—	—	—	—
Magnesia ...	0.01	—	—	—	—	—	—	—
Potash ...	0.05	—	—	—	—	—	—	—
	6.90	3.79						
Total iron in ore ...	43.02	38.56	38.95	49.78	37.91	40.80	42.53	48.30

Notes.—¹ Mean of five determinations.⁵ With trace of iron.² Another determination gave 0.62.⁶ Si 4.0, Al 1.97.³ Mean of two determinations.⁷ 0.015 ?⁴ Another determination gave 3.89.

I.—J. Spiller in 'Iron Ores of Great Britain' (*Mem. Geol. Surv.*), 1856, p. 57. West Level. An altered spathose ore, in which the greater part of the carbonate had been converted into hydrated peroxide.

II.—A. Dick in *do.*, p. 59. Rispey. Spathose ore; easily scratched by the file. No metal ppt. by H₂S from the HCl solution of 1,000 grains of ore.

III.—Dr. Percy in L. L. Bell, 'On the Manufacture of Iron in connexion with the Northumberland and Durham Coalfield.' *Rep. Brit. Assoc. for 1863 (1864)*, p. 756. Spathose ore from Weardale.

IV.—Same authority as III. Hydrated peroxide from Weardale. A trace of protoxide of copper.

V.—Weardale Steel, Coal and Coke Co., Ltd., Carrieks Mine, raw ore.

VI.—" " " " dry ore.

VII.—" " " " Sunnysbrow Mine, raw ore.

VIII.—" " " " dry ore.

The white carbonate of iron is more valuable than the brown hæmatite. The composition of the carbonate is shown by the

following partial analyses of mineral from Carricks Mine in 1915:—

							Raw.		Dry.
Fe	...	...	...	...	...	...	41.23	...	41.30
SiO ₂	...	...	...	...	...	...	0.90	...	0.90
H ₂ O	...	...	...	...	...	...	0.16	...	—

The ironstone occurs in veins and flats in the upper part of the Carboniferous Limestone Series, and is confined to the limestone-beds. The following section, at Burtree Pasture Mine, Level Head Engine Shaft, a little more than a mile north of Wear Head, is summarised from the detailed section published on Vertical Sections Sheet 63 (*Geol. Surv.*). It may be taken as illustrative of the Weardale succession between the Little and Tyne-Bottom Limestones:—

Little Limestone	...	...	...	...	...	...	...	Ft.
Strata	...	...	...	...	...	...	...	9
Great Limestone	...	...	...	...	...	...	...	52
Strata	...	...	...	...	...	...	...	67
Four Fathom Limestone	...	...	...	...	...	...	...	83
Strata	...	...	...	...	...	...	...	18
Three Yard Limestone	...	...	...	...	...	...	...	89
Strata	...	...	...	...	...	...	...	10
Five Yard Limestone	...	...	...	...	...	...	...	48
Strata	...	...	...	...	...	...	...	15
Scar Limestone	{ Limestone ... 6 ft. 9 ins. } { Plate ... 3 ft. 3 ins. } { Limestone ... 23 ft. 0 ins. }						...	63
Strata	...	...	...	...	...	...	...	33
Tyne-Bottom Limestone	...	...	...	...	...	...	...	67
	...	...	...	...	...	...	...	3½

Where a vein cuts strata other than limestone the iron-ore fails altogether, or is reduced to a mere streak of perhaps an inch in width. Fluorspar and galena, however, which sometimes occur in the same veins as the ironstone, are not entirely confined to the limestones. Galena is sometimes found in the midst of ironstone and, very rarely, forms strings in it, an inch or two in thickness. On an old mine-plan, iron, fluor and lead are recorded as occurring together, but this association has not been observed in any of the veins now being worked. The name 'rider' ore has been given to ironstone found in lead-bearing veins as ribs on one or both sides of the galena.¹

Ironstone appears or fails unexpectedly. Failure is due to the vein being nipped out by country-rock, or occasionally to its being filled up with lumps of country-rock to the exclusion of ore. Veins that have failed are not usually followed, but some have been proved to become productive again.

In Weardale the iron-ore occurs generally in the Great Limestone, but has been found also in the Four Fathom Limestone, and, as reported, in still lower bands. It occupies fissures, some of which are evidently faults, while others are joints widened by the solvent action of water, like the 'rakes' of Derbyshire.²

¹ J. D. Kendall, 'Iron Ores of Great Britain,' 1893, p. 142.

² 'Geol. of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of N. Derbyshire.' (*Mem. Geol. Surv.*), ed. 2, 1887, p. 121.

According to J. D. Kendall,¹ the presence of 'rider' ore in a vein depends upon the character of the walls. For example, if one be limestone and the other sandstone, faulted into apposition, the workable rider accompanies the limestone-wall only. If both walls are of limestone, and the vein carries lead, there are usually two ribs of rider, one on each wall, the galena being between them; or the rider may extend from wall to wall in the absence of lead, as was the case on the Manor House Vein in the Scar Limestone, near Alston Station.

'Flats' are masses of ore projecting from the vein into the limestones for several feet or yards and having usually the same inclination as the limestone beds. In the Great, and also in the Scar Limestone, Kendall² recognises three levels in which the vein usually 'flats,' and which are known as the upper, middle and lower flats. As a rule flats are more important than the veins, but Lowe's Vein, Carricks Mine (p. 8) is exceptionally wide and can be worked profitably apart from them.

That the ore has been formed by metasomatic action on the limestone admits of little doubt. Generally it graduates into limestone, but at Carricks Mine there is said to be frequently a thin layer of clayey material, containing about 40 per cent. of iron, between the two.

Flats have various shapes; they may be either wedge-shaped or short and thick. Sometimes they extend along a cross-vein, which may cut another main vein. At the intersection of veins there is sometimes a widening of the ore-body. In Weardale, veins are generally too narrow for profitable working apart from flats.

Usually the workable height in the vein is only about 20 ft., but the ore may be present throughout the whole thickness of the Great Limestone, which in Weardale varies from 53 to 67 ft. The ore-body ends above and below in various ways. It may abut sharply against the shale overlying the limestone, or against the soft sandstone ('tuft') that usually underlies it, or it may rapidly narrow to a mere streak as the limestone boundary is approached. The usual height of a flat in the same district is about 20 ft., although some are as high as 32 ft.

In the early issues of the Mineral Statistics the output of Weardale is not separated from that of neighbouring areas. In 1861 the output was 91,000 tons and in 1862 it was 124,750 tons, according to Bell.³ From 1869 onwards statistics⁴ are available and are as follow:—

Tons.			Tons.			Tons.		
1869	...	30,000	1874	...	85,491	1879	...	16,679
1870	...	100,322	1875	...	34,828	1880	...	41,358
1871	...	89,349	1876	...	24,202	1881	...	70,771
1872	...	97,953	1877	...	51,344	1882	...	82,600
1873	...	99,393	1878	...	35,619	1883	...	48,109

¹ 'Iron Ores of Great Britain,' 1893, p. 142.

² *Loc. cit.*

³ 'On the Manufacture of Iron in connexion with the Northumberland and Durham Coalfield,' *Rep. Brit. Assoc.*, 1863, p. 758.

⁴ 'Mineral Statistics of the United Kingdom' (*Mem. Geol. Surv.*), annually to 1881. After 1881 replaced by 'Mines and Quarries: General Report with Statistics' (*Home Office, Parliamentary Papers*), annually.

	Tons.		Tons.		Tons.
1884	... 48,372	1895	... 19,064	1906	... 12,961
1885	... 39,777	1896	... 19,277	1907	... 13,791
1886	... 1,759	1897	... 16,852	1908	... 12,594
1887	... 2,506	1898	... 20,868	1909	... 10,471
1888	... 47,203	1899	... 16,960	1910	... Nil.
1889	... 3,991	1900	... 19,046	1911	... 3,955
1890	... 11,488	1901	... 19,503	1912	... 3,033
1891	... 7,715	1902	... 21,121	1913	... 36
1892	... 9,275	1903	... 13,468	1914	... 1,776
1893	... Nil.	1904	... 21,146	1915	... 10,729
1894	... 2,679	1905	... 12,693	1916	... 13,170

DETAILS OF THE MINES

CARRICKS MINE

The Weardale Steel, Coal and Coke Company, Limited, Spennymoor.

A day-level, situated at Cold Knuckles, half a mile south-west of Ireshopeburn. Nearest railway-stations: Wearhead, and St. John's Chapel (N.E.R., Wear Valley Branch), each about $1\frac{1}{2}$ miles distant.

Ordnance and Geological Maps: One-inch New Ser., 25 (Old Ser., 102 N.E.); six-inch Durham, 22 S.E. and 30 N.E. Lat. $54^{\circ} 44' 10''$. Long. $2^{\circ} 12' 55''$.

The mine was originally worked for lead and was then called Craigs Level. It was taken over by the present owners about 1883.

Geological Conditions

The mine-entrance is situated on the outcrop of the Great Limestone, and the level is driven south-eastward. The dip of the limestone is towards the north-west at an angle slightly greater than that of the day-level. The iron-ore is found in several veins trending south-west and north-east. The day-level cuts the veins in succession at right-angles, but, owing to the slightly higher dip of the strata, falls a little below the limestone after leaving the entrance, and at Lowe's Vein is some 25 ft. below it. The veins taken in the order in which they are cut by the level are: Groove Heads Vein, unworked; Wilson's and Carr's Veins, both unproved; a nameless vein that passes through Rowantree A Mine and is not worked; Lowe's, Dawson's, Madison's and Far Veins, the last standing idle at the time (1917). Lowe's, Dawson's and Madison's Veins were the only ones being worked in July, 1917.

Lowe's Vein has an average width of 14 ft.; the other two of from 3 to 10 or 12 ft. All the veins are faults with downthrows to the north of 10 ft. or a little more. Cross-veins have a small downthrow on the east side.

The ore filling the veins is arranged in horizontal bands. Layers of hard crystalline and soft material alternate, the latter sometimes containing geodes. It is said that the 'posts' (individual bands) of the Great Limestone, which are constant over a wide area, can be recognised in the ironstone, on the evidence of a correspondence in thickness. It is stated also that the posts in the ironstone lie a little below the corresponding posts

in the adjacent limestone, indicating that the ironstone occupies narrow fault-troughs. The dip of the limestone sags slightly towards each vein.

Galena occurs in any part of the ironstone and needs to be picked out, the lead approximately paying for the expense of picking. A concentric structure is often seen in the ironstone and may occur in any part of the vein. There are also small cavities that may contain spar.

When the vein leaves the Great Limestone, only a parting of ferruginous material is seen, but the vein may open out again in another limestone and may then contain galena or fluorspar.

Mining Details

Access to the mine is gained by a day-level, which is about 6 ft. high and from $3\frac{1}{2}$ to 5 ft. wide. It extends to a total length of about $1\frac{1}{4}$ miles, but beyond Far Vein is not ventilated. It slopes at about 1 in 100 towards the entrance. Where it cuts the veins, 'rises' are put up into the ore-body in the Great Limestone above. Main levels are then developed in the veins at right-angles to the adit, but of course above it. The width of a level depends upon that of the vein it is in, and may be 10 ft., but never more than 12 ft. on account of difficulty in timbering. The height of the levels is 20 ft.; if the ore should have a greater vertical extension than this, another level would be made. Ore is thrown down the 'rise' into tubs in the day-level. Timber is used only for the roofs, and part of it is recovered; but by the time the men are retreating it may be 30 or more years old.

The ore is got by overhand stoping, and blasting is necessary. More or less horizontal 'jointing' in the ore causes the stopes to vary in height. These 'joints' have been mentioned above as corresponding to stratification in the country-rock, according to local belief. Unless a fall occurs, stopes are left empty. The veins are not wide enough to need pillars.

When a flat is found, a main level is run into it at right angles to that in the vein, and is continued until the end of the flat is reached, when the level is turned through a right-angle and continued parallel to the vein until country-rock is again met with. Another right-angled turn brings the level back to the vein. The extent of the flat being thus marked out, the ore is got, commencing with the part farthest from the vein.

The day-level takes all the water and this is not excessive. Lowe's vein was found to be perfectly dry in the working-places. There is practically no waste material in the ore. The maximum of impurities is 4 to 5 per cent.

The output of brown hæmatite in July, 1917, was about 1,500 tons a month and could be increased by extra labour. In 1916 some 300 tons of vein-stuff yielded about 7 per cent. of galena. Lead is sporadic in its occurrence.

The terminations of the veins have not been ascertained. In the case of *Lowe's Vein*, working extends about 154 yards eastwards from the 'rise' by which it is reached from the day-level, and in the opposite direction for about 82 yards; but of this latter section about 30 yards is in limestone that suddenly

replaces the ore. The ironstone comes in again beyond this section with equal suddenness. In the eastern part of the vein a cross-vein has been followed for a few yards, when it is cut off by a vein of ore parallel to the main one.

The Groove Heads Vein may have been worked out west of the day-level; towards the east the easterly dip carries it below water-level.

Dawson's Vein has been worked out east of the day-level. West of the level, pillars in the flats are standing ready for retreating, but it is now hoped to go still farther west before removing them.

Madison's Vein is worked on the east side of the day-level and in north and south cross-veins on the west side. It is intended to explore the vein towards the west, but at present it is poor in that direction.

The Far Vein has been worked for a considerable distance, but is at present standing idle owing to shortage of labour.

HOPE LEVEL

The Weardale Steel, Coal and Coke Company, Limited, Spennymoor

A day-level, situated at Ashes House, half a mile north-west of Stanhope Church. Nearest passenger-station: Stanhope (N.E.R.). For goods traffic: Stanhope Kiln Mineral Siding, on the mineral railway that joins the North Eastern System at Burn Hill Station and connects by an incline with the North Eastern Railway in Weardale.

Ordnance and Geological Maps: One-inch New Ser., 26 (Old Ser., 103 N.W.); six-inch Durham, 24 N.W. and S.W. Lat. $54^{\circ} 45' 9''$. Long. $2^{\circ} 0' 52''$.

Hope Level has been described in the Memoir on Fluorspar,¹ but the information here given is later than that account. The level is being explored for iron, the expenses being covered by the fluorspar obtained. The mine is known to have been worked in 1855, and there is information of extensive flats having been found and of iron-ore being left when the mine was abandoned owing to trouble with water and foreign competition.

The day-level was driven in a north-eastward direction to the Red or Crawley Vein. The vein is a fault with a downthrow northwards of about 17 ft.

Exploration is carried out by surface-trenches, boreholes and drifts. At present (July, 1917) work is being done from the point where the level cuts the vein in the Four Fathom Limestone. After proceeding one or two hundred yards a rise is being put up to unwater the Great Limestone, in which iron-ore is expected to be found.

SUNNYBROW MINE

The Weardale Steel, Coal and Coke Company, Limited, Spennymoor

Situated about 150 yards south-west of Sunny Side,² three-quarters of a mile north-west of St. John's Chapel.

¹ 'Special Reports on the Mineral Resources of Great Britain.' (*Mem. Geol. Surv.*), vol. iv, ed. 2, 1917, p. 18.

² Not the 'Sunny Side' and 'Sunny Brow' 700 yds. N. of St. John's Chapel.

Ordnance and Geological Maps: One-inch New Ser., 25 (Old Ser., 102 N.E.); six-inch Durham, 23 S.W. Lat. $54^{\circ} 44' 43''$. Long. $2^{\circ} 11' 25''$.

The ironstone lies in the Great Limestone. The present output of brown hæmatite (July, 1917) is about 100-150 tons monthly. The ore is carted to Wearhead Station, $1\frac{1}{2}$ miles distant.

In addition to the mines described above, there are in Weardale a number of small mines and quarries that have been worked in the past for ironstone, such as Rowantree A, Rowantree B, and the Far Cut, in six-inch map Durham 22 S.E.; Brandon Walls, Bog House, and Hanging Wells, in 23 N.E.; and Slit Pasture, West Rigg, Rigg, Heights, and Level Gate, in 23 S.W.

TEESDALE

The Home Office Statistics give the following outputs of iron-ore in Teesdale:—

1882 ...	...	Sraigsill, 1,000 tons ;	Ettersgill, 126 tons.
1883 ...	...	" 639 tons ;	" 1,500 tons.
1884 ...	...	"	500 tons.

Both localities are in Co. Durham, in the parish of Middleton, and the ore is described as spathose ore and siliceous hæmatite. Snaigsill House is situated a mile north of Middleton (New Series one-inch Sheet 31); Ettersgill Common is $3\frac{1}{2}$ miles south of St. John's Chapel (Sheet 25). It is probable that the ore was obtained from the Great Limestone, which crops out in Snaigsill.

ALSTON DISTRICT, CUMBERLAND

GENERAL ACCOUNT

The conditions under which ironstone occurs in the Alston District are similar to those found in Weardale, and the general account given under that locality applies to Alston also. In the latter district, however, according to Kendall,¹ iron-ore occurs in the Tyne-Bottom and Sear Limestones as well as in the Great Limestone. At Kilhope Fell, Nenthead, it has been worked in the Fell-Top Limestone (the highest limestone below the Millstone Grit), which locally "becomes ferruginous, probably owing to its being intersected by a considerable number of small veins carrying 'iron riders.' The brown hæmatite ore occurring in this limestone varies from 3 to 7 ft. thick, and is of good quality."² At Nenthead a bed of brown hæmatite, about 7 ft. in thickness, occurs in the Little Limestone, but the quality of the ore is very variable.³

At Nenthead amorphous carbonate of iron was worked by Messrs. Bell Bros., Limited, and smelted at Wylam.⁴ The iron obtained here, as well as from other carbonates and oxides in the same district, was of excellent quality, but the supply was uncertain and the working costly. The ore in the veins themselves, when

¹ *Op. cit.*, p. 142.

² R. Meade, 'Coal and Iron Industries of the United Kingdom,' 1882, p. 417.

³ *Loc. cit.*

⁴ I. L. Bell, 'On the Manufacture of Iron in connexion with the Northumberland and Durham Coalfield,' *Rep. Brit. Assoc.* for 1863 (1864), p. 734.

pure, yielded perhaps 30 per cent. or more of iron; but it gradually passed into carbonate of lime, from which it was with difficulty distinguished.

The earliest 'Mineral Statistics' that contain the outputs of iron-ore, those of 1855, mention Alston as an iron-producing district. In the following year the output of Alston Moor was separated in the Statistics from that of other places, and is given annually from 1856 until 1875. From that time onwards, except for 90 tons of ore from Ardale Head, Ousby, in 1886, and 112 tons from Garrigill and Nenthead in 1889, no outputs appear in the Statistics.

Output of Alston Moor.

Tons.				Tons.			
1856	...	...	...	8,089	1864	...	500
1857	...	...	...	10,113	1867	...	25
1858	...	...	...	17,694	1869	...	140
1859	...	...	...	1,871	1870	...	1,349
1860	...	...	...	1,931	1871	...	1,683
1861	...	...	...	101	1873	...	3,032
1862	...	...	...	820	1874	...	3,029
1863	...	...	...	891	1875	...	1,151

Iron-ore has been obtained near Alston from the Manor House and Park or Horse Edge veins.

W. W. Smyth¹ mentions that at Allenheads carbonate of iron occurs both in the regular lodes and in flats, becoming more abundant in the direction of Weardale. At Rodderup Fell, a rich lode known as the Craig Green or Bracken Syke Vein, in the Scar Limestone, is from 16 to 20 ft. wide, and in it iron locally takes the place of lead.²

On the moors of East Cumberland, and on the top of the Melmerby Scar Limestone, many poor lead-lodes occur, ranging a little north of east-north-east. Nearly all of them contain brown oxide of iron when lead fails.³ Various levels driven into the hill-side on the east side of the South Tyne, and from the col where that river rises as far as the Tees, have cut through the lead-belt into higher rocks productive only of iron-ore of little value. Samples of the deep-seated ores, both at Tyne Green and under the summit of Cross Fell, averaged only 33 per cent., but specimens from the weathered waste-heaps averaged 44 per cent. of iron. "Eastward, the iron in Sir John's and Tyne Green veins becomes rather siliceous, but parallel lodes in the adjacent manor of the Duke of Cleveland yield good brown peroxide of iron, which is being accumulated in great heaps against the day when Middleton and Alston shall be joined by a railway."⁴

We may mention, in this place, that the Home Office Statistics record 10 tons of ironstone from Middle Fell, Brough, Westmorland, in 1888; and from Longrigg Mine, Westmorland, 8,000 tons of hæmatite in 1877 and 1,454 tons in 1879.

¹ 'The Iron Ores of Great Britain' (*Mem. Geol. Surv.*), pt. i. 1856. p. 18.

² J. A. Phillips, 'A Treatise on Ore Deposits,' ed. 2. by H. Louis, 1896, p. 245.

³ C. E. De Rance, 'On the Occurrence of Lead, Zinc, and Iron Ores in some Rocks of Carboniferous Age in the North-west of England,' *Geol. Mag.*, 1873, pp. 303-309.

⁴ *Ibid.*, p. 305.

DETAILS OF THE VEINS

The following account deals with certain veins that were being prospected in 1917:—

HORSE EDGE VEIN, ALSTON

The Alston Prospecting Syndicate, Limited, 170, Winchester House,
Old Broad Street, London, E.C. 2.

(Prospecting)

Trials near Horse Edge, 6 miles north-east of Melmerby, and 2,000 yards due west of 'Cross House' on the Penrith Road from Alston. Nearest Station: Alston (N.E.R.), $3\frac{1}{2}$ miles towards the north-east.

Ordnance and Geological Maps: One-inch New Ser., 24 (Old Ser., 102 N.W.); six-inch Geological, Cumberland 33 S.E. and 41 N.E.

The vein is said to be in the Great Limestone and to range north-east and south-west. At one point it hades towards the south-east at an angle of about 30° , but at another, supposed to be on the same vein, it is nearly vertical. The most distant trial-hole is believed to be on a cross-vein. The width of the main vein is stated to average from 30 to 35 ft. North-eastwards the veins have not been recognised beyond the fault (shown on the Geological Survey Map) that runs from N.W. to S.E. between Horse Edge and Park Fell. Towards the south-west their termination is not known. The outcrop of the vein, or veins, had been prospected at intervals over a distance of about 400 yards by trenches, shafts, and tunnelling and cross-cutting from the bottoms of the shafts. A pair of shafts were put down in one place on the cheeks of the vein to find its width. The overburden averages 6 ft., but limestone 'tumblers' are occasionally met with as far down as 40 ft. Small pieces of galena and barytes occur in the waste-heaps. At the trial farthest from Alston the ore is more earthy than elsewhere and is said to be phosphoric. The ore varies and would need washing or kibbling. It is intended to put up an aerial rope-way to Alston Station.

WOODLANDS LEVEL, PARKSIDE MINES

The Hedworth Barium Company, Limited, 1, St. Nicholas Buildings,
Newcastle-on Tyne

(Prospecting)

A day-level situated east of Mark Close, on the western side of the South Tyne, about a quarter of a mile north-west of Alston Church.

Ordnance and Geological Maps: One-inch New Ser., 25 (Old Ser., 102 N.E.); six-inch Cumberland, 33 S.E. Approx. Lat. $54^\circ 48' 55''$. Approx. Long. $2^\circ 26' 40''$.

The mine having been abandoned about 1872, the workings had fallen in. Work was recommenced in March, 1917, and by July about 200 yards of the level had been repaired.

The level is driven westward in boulder-clay, but it was hoped that solid rock would be reached in a short distance and that a 'flat' of ore, reputed to have been left by the old workers, would be struck. So far the old plan had been found accurate.

The vein probably runs south-westward in the Scar Limestone, and is presumably either the Park Grove Vein or the Park Grove Sun Vein shown on the Geological Survey Map.

ARDALE HEAD, OUSBY.

The Cargo Fleet Iron Company, Limited, 35, Lime Street, London, E.C. 3
(Prospecting)

Trials situated at the head of the gorge of Ardale Beck, between Ousby Fell and Skirwith Fell, some 3 miles E.N.E. of Ousby. Nearest railway-station: Langwathby (M.R.), about 8 miles by road in a westward direction. The site is about 2,400 ft. above O.D., and the more westerly vein is but 100 yards from the gorge.

Ordnance and Geological Maps: One-inch New Ser., 24 (Old Ser. Geol., 102 N.W.); six-inch Cumberland; 51 N.E. Lat. $54^{\circ} 42' 55''$. Long. $2^{\circ} 30' 35''$.

Ardale Head is recorded in the Home Office Statistics as having yielded 90 tons of 'red hæmatite' in 1886.

In July, 1917, it was said that two veins had been proved in the Great Limestone about a quarter of a mile apart and running N.W.-S.E. approximately, parallel to the outcrop of the beds. The thickness and extent of the veins were as yet unproved. The more westerly has a hade of about 45° . The country-rock dips about 1 in 12 in a more or less easterly direction. Prospecting was being carried on by trenches. If this proves successful, an adit will be made below and at right angles to the veins, and rises put up.

The ore is a brown hæmatite said to contain on the average about 48 per cent. of iron and from 7 to 9 per cent. of manganese. Ore dug in the previous period of working has been left stacked on the ground, no doubt on account of the difficulty of transport. It is proposed to make a tramway on the south side of Ardale Beck to join the Midland Railway somewhere near Langwathby.

CHAPTER III

NORTH WALES, DERBYSHIRE, AND THE ISLE OF MAN

NORTH WALES

BY T. C. CANTRILL AND R. L. SHERLOCK

GENERAL ACCOUNT

In North Wales small masses of hæmatite are associated with the Carboniferous Limestone and more rarely with the Carboniferous Basement Beds. The following account is based on the Geological Survey Maps and Memoirs.¹ The mines visited (in August, 1917) for the purpose of the present report are Dyserth and Cwm, Bodfari, and Ty'n-y-caeau, as being those most likely to be reopened. No ore was then being raised from any of the North Wales hæmatite mines.

The Carboniferous Limestone Series of Flintshire presents a certain sequence of lithological types, graduating one into the other, but recognisable over wide areas. The iron-ores are confined almost wholly to the lower part of the series, and are developed in them only where suitable conditions prevailed. They are associated with copper in small quantities, and in one locality with nickel and cobalt. Ores of lead and zinc, on the other hand, are confined to the upper part of the series and are not associated with ores of iron.

In the northern part of Flintshire, and in parts of the adjacent counties on the west, a district to which the iron-ores are confined, the sequence referred to may be briefly described as follows:—

4. An upper part in which are included thin-bedded black limestones.
3. A central part of massive grey and white limestones, from the upper part of which most of the lead-ore has been obtained.
2. A lower part, which consists of dark argillaceous limestones and shales, passing down into
1. Basement conglomerate, locally coarse and of great thickness, but elsewhere represented only by red shales with little conglomerate.

Most of the occurrences have been found in the lower part of 3 and in 2, but in one outcrop ore has been worked in the lower part of 1.

The ore in 3 and 2 usually occupies chambers or irregularly widened-out spaces in joints or faults, and is comparable in mode of occurrence, and presumably in origin, with the ores of West Cumberland. In 1 it has replaced a thin impure limestone, which lies close to the base of the conglomerate.² This limestone has

¹ One-inch Old Series Sheets 79 N.W., N.E., S.W., S.E. and 74 N.E. 'The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn' (Explanation of Sheet 79 N.W.), 1885, and 'The Geology of the neighbourhoods of Flint, Mold, and Ruthin' (Explanation of Sheet 79 S.E.), 1899.

² A. Strahan and A. O. Walker, *Quart. Journ. Geol. Soc.*, vol. xxxv, 1879, p. 268.

only a local development, and its replacement by iron-ore has taken place locally along faults and, to a less degree, along part of the outcrop.

The earliest return of hæmatite raised in North Wales appears in the Mineral Statistics for 1857. From that date until 1913 one or more mines had a small output in most years. The ten-year period from 1907-1916, inclusive, produced 7,357 tons, the best year being 1911, with an output of 2,333 tons. Details of output for the individual mines are given later, under the descriptions of the mines.

The reserves are not likely to be considerable, for no large body of ore has been found in any part of North Wales. Explorations are proceeding in the Dyserth and Cwm district and at Ty'n-y-caeau; otherwise the mines are dormant or extinct.

DETAILS OF THE MINES

DYSERTH AND CWM DISTRICT

MOEL HIRADDUG MINE, NEAR DYSERTH

A group of shafts and opencaſt workings situated on the top and eastern slopes of the hill and extending north and south for about 800 yards (Fig. 1, p. 17).

One-inch New Series Ordnance Map 95; Old Series Geological, 79 N.W.; Six-inch Geological, Flintshire 4 N.E. and 5 N.W. Lat. $53^{\circ} 17' 25''$ to $53^{\circ} 17' 53''$. Long. $3^{\circ} 23' 50''$ to $3^{\circ} 24' 25''$.

The working of iron-ore in open pits on this hill has been attributed to the Romans on the evidence of the discovery of a Roman sword and helmet. The first return of ore raised was made to the Mining Record Office in 1860.

The ore occurs as nodules of dark, hard, almost pure peroxide of iron in a red ferruginous clay which, being washed away, leaves smaller grains containing about 1 per cent. of titanium oxide. It is found in pockets or widened-out spaces in joints ranging about north-north-west. The pockets are irregular in shape, but generally bounded by curving vertical walls like those of a swallow-hole. Downwards they are usually terminated at a slight depth from the surface (rarely exceeding 60 yards) by the rapid closing in of the walls. They are said to be richer in their contents near the top of the hill than at the base, where they are too poor to repay working.

One of the principal joints in this hill is known as the Main Joint, and has been followed for a distance of about 200 yards along the east slopes, and to a depth of 60 yards. It yielded ore containing on the average 50 per cent. of metallic iron. Other old workings occur near the top of the hill, and nearer the junction of the Limestone with the Basement Beds on the south side.

The hæmatite of some of the joints is associated with small quantities of nickel and cobalt ores, which were described in this connexion by C. Le Neve Foster¹ in 1882. The principal joint containing these ores was distinguished by its direction, which was N. 33° E., and by a tendency to open out downwards after showing a tendency to close. It was worked from 1870 for a few years

¹ *Trans. Roy. Geol. Soc. Cornwall*, vol. x, pt. iv, p. 107.

for nickel and cobalt to a reputed depth of 240 ft. In another case manganese occurred without traces of nickel and cobalt.

In September, 1917, trial shafts were being sunk on the eastern slopes of the hill. Two were reported to have reached depths of 48 and 57 ft. respectively. The old opencast is 40 or 50 ft. deep.

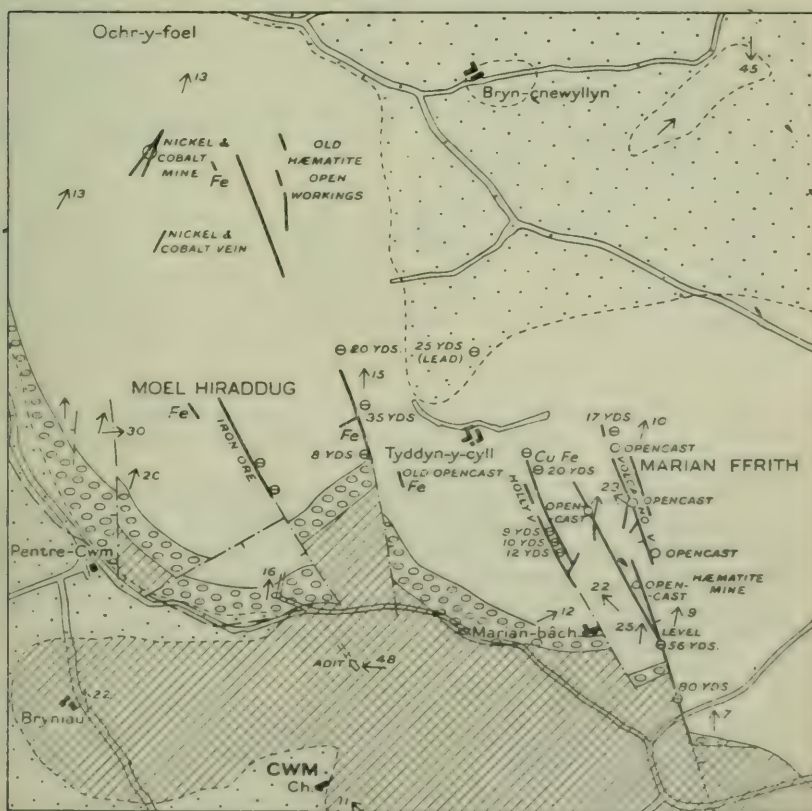
The output from Moel Hiraddug has not been separately recorded.

CWM IRON MINE

A group of shafts and opencast workings on Marian Ffrith, half-a-mile north-east of Cwm Church (Fig. 1).

One-inch maps as for Moel Hiraddug; six-inch Geological, Flintshire 5 N.W. Lat. $53^{\circ} 17' 10''$ to $53^{\circ} 17' 33''$. Long. $3^{\circ} 23' 30''$.

FIG. 1.—Map of Iron-mining District, Cwm, near Dyserth, Flintshire.



These workings have been opened along faults, which "run in general about N. 15° W., and have the effect of throwing the limestone down to the east about 30 yards. The ore occurred partly in veins and partly in large chambers or pockets hollowed out in the lowest bed of limestone, where it rests upon the red shales and conglomerates of the Basement Beds. The underlying Wenlock Shale was entered to a depth of 20 yards in the No. 1 Shaft. The ground has now fallen in in the greatest confusion in consequence of the working out of the irregular deposits of ore."¹

In the years 1860-75, inclusive, the mine is shown in the Mineral Statistics to have yielded at least 22,831 tons, the first return being 4,100 tons in 1860; but in 1885 little was being done beyond sinking shallow trial-shafts on the numerous joints in the neighbourhood. It was then reported "that about 6 tons of copper ore were raised from a joint about 150 yards east-south-east of Tyddyn-y-cyll. An attempt was made to drive a day-level under this ground from the ravine north of Cwm, 150 yards south of the Marian road, but was abandoned after penetrating to a distance of about 130 yards in Wenlock Shale. Further north there have been several trials along the base of the limestone and in the red Basement Beds, but without any result."

The following figures, taken from the Mineral Statistics, show the output of the Cwm Mine:—

Year.			Tons.	Year.			Tons.
1860	...	...	4,100	1865	...	...	?
1861	...	...	4,000	1872	...	...	4,430
1862	...	...	?	1873	...	...	3,860
1863	...	...	?	1874	...	...	1,039
1864	...	...	5,377	1875	...	...	25

HENFRYN MINE

Shafts and opencasts situated at Henfryn, 1¼ miles east of Dyserth Church. Six-inch Geological Map, Flintshire 5 N.W. Lat. 53° 18' 10". Long. 3° 23' 5".

"In the years 1872-75 a poor ore (averaging about 30 per cent. of metallic iron) was worked at Henfryn. It was found in veins running a little west and a little east of north, and is associated with a mangiferous ochrey clay, and with traces of copper pyrites."² The quantity of ore sold amounted to 340 tons 10 cwt., according to the Mineral Statistics.

CAERWYS DISTRICT

The following trials and disused mines are situated near Caerwys. All fall within the area of the one-inch New Series Ordnance Sheet 108; Old Series Geological Map 79 S.E.; and six-inch Geological, Flintshire 8 N.E. The descriptions are quoted from the Geological Survey Memoir.³

Gledlom Iron Mine.—Situated half a mile E.S.E. of Ysceifiog church. Lat. 53° 13' 53". Long. 3° 15' 24".

¹ 'The Coast adjoining Rhyi,' etc. (*Mem. Geol. Surv.*), 1885, p. 53.

² *Ibid.*, p. 54.

³ 'Geol. of Flint, Mold, and Ruthin,' 1890, p. 198.

"A vein runs north and south and underlies west, but the ore occurred in pockets and was worked partly in open trenches, while the shafts reach a depth of 52 to 55 yards. The ore, which amounted to about 150 tons a month for nine years, was sent to Darwin" [Darwen].

Llwyni Iron Mine.—Situated half a mile east of Ysceifiog church. Lat. $53^{\circ} 14' 2''$. Long. $3^{\circ} 15' 32''$.

This mine "lies 300 yards north-west of the last-described. The vein, or rather cavity, runs north-west, and has been dug completely out for about 40 yards, while at either end of it a shaft has been sunk to a depth of about 50 yards. A strong north and south joint brought in a different ground at the north end of the cavity."

Caerwys.—A trial-shaft for hæmatite is situated on the high-road 350 yards north of the centre of the town. Another trial is situated 500 yards S.W. of the same point, and a third trial in a ravine, 720 yards W. 20° S. from the town.

Bryn-Sion.—Situated $\frac{3}{4}$ mile S. 35° E. from Caerwys. Lat. $53^{\circ} 14' 12''$. Long. $3^{\circ} 17' 44''$. "At Bryn-Sion . . . the ore occurs in a joint running a little west of north for about 100 yards, and was worked for a short time for the Brymbo Ironworks."

Pant-gwyn.—Situated half a mile N.E. of Ysceifiog church. Lat. $53^{\circ} 14' 25''$. Long. $3^{\circ} 15' 41''$. At Pant-gwyn the ore "lies in a small north and south fault crossing a ravine. Two shafts in the bottom of the ravine attain a depth of 31 yards and one on the top of 44 yards, with a cross-cut 21 yards westwards into the vein. The vein at the bottom of the shafts underlay west, was 7 ft. broad, and composed of a layer of iron-ore on either side, and of loose blocks in the centre. Little or no ore was ever sold from here, and the works were abandoned about the year 1873."

THE VALE OF CLWYD DISTRICT

BODFARI MINE

Situated a quarter of a mile N.N.W. of Bodfari church, 4 miles N.E. of Denbigh Station (Fig. 2, p. 20).

One-inch New Ser. Ordnance 107; Old Ser. Geological 79 S.W.; six-inch Geological, Flintshire 8 N.W. and 8 S.W. Lat. $53^{\circ} 13' 20''$ to $53^{\circ} 13' 28''$. Long. $3^{\circ} 21' 23''$ to $3^{\circ} 21' 45''$.

The mine lies in a small area of Carboniferous Limestone about 500 yards wide from west-south-west to east-north-east, and 800 yards long. The limestone is bounded on the west by the Vale of Clwyd Fault, which throws it against Bunter; on the north and east by faults throwing it against Wenlock Shale; on the south it disappears under a river-terrace and alluvium. In addition, a fault, carrying barytes, runs in the limestone parallel to the eastern boundary and about 90 yards west of it. The limestone has been partly and quite irregularly converted into hæmatite. The workings are situated on the north-eastern part of the outcrop, where the limestone is bare of superficial deposits. The six-inch Geological Map dated 1877-80 shows a number of opencasts, also shafts, from 18 to 22 yards deep, one disused and seven working. The only data obtainable

relating to the history of the mine are those of output in the Mineral Statistics. From 1877 to 1883, inclusive, 5,770 tons were raised. From 1897 to 1909 the total output was 8,743 tons, the

FIG. 2.—Map of Iron-mining District, Bodfari, Flintshire.

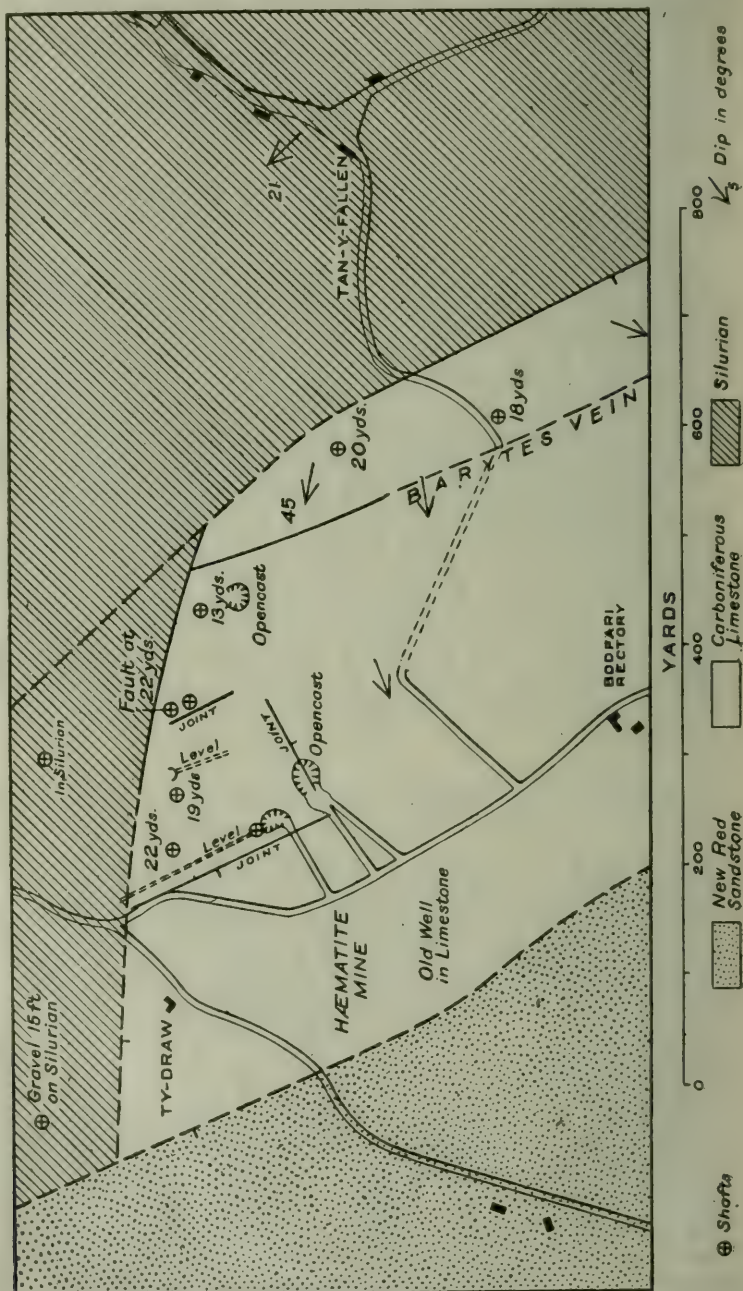


figure for the last year being 150 tons. The average percentage of iron is given for 1897-8 as 25, for some later years as 30 to 32, and for 1909 as 45.

DINGLE MINE¹

Situated 3 miles west of Llandegla and 4 miles S.S.E. of Ruthin.

One-inch New Ser. Ordnance 121; Old Ser. Geological 74 N.E.; six-inch Geological, Denbighshire 26 N.E. Lat. $53^{\circ} 3' 26''$. Long. $3^{\circ} 16' 28''$.

A deposit of hæmatite occurs in a shattered and heavily slickensided belt of limestone that runs E. 25° N., parallel to the Dingle Fault. The line of crush passes south of Ty'n-llwyn (about 200 yards west of Dingle) and eastward as far as the Vale of Clwyd Fault. The deeper parts of the rock seem to be the richest in hæmatite.

The rock was first quarried and then a large underground gallery, 30-40 yards long and 9-10 ft. high, was driven eastward along the belt. A level also was driven southward from a point about 100 yards north of the quarry, to win the deposit at lower depths, and a trial-shaft reached the ore almost at the point where it runs out against the Vale of Clwyd Fault.

The hæmatite is a low-grade ore and contains a small percentage of manganese. It did not pay to work, as haulage was too expensive. The mine was abandoned over 50 years ago.

ABERGELE DISTRICT

TY'N-Y-CAEAU IRON ORE MINE

Messrs. Jaeger Brothers, 8, Union Court, Old Broad Street, London, E.C. 2

A slant or slope about 150 yards west of Ty'n-y-caeau² Farm, 2 miles south-west of Abergele (Fig. 3, p. 24). Railway-station: Abergele and Pensarn (L. and N.W.), $3\frac{1}{2}$ miles by road.

One-inch New Ser. Ordnance Map, 107; Old Ser. Geological, 79 S.W.; six-inch Geological, Denbighshire 4 S.W. and S.E. Lat. $53^{\circ} 15' 38''$. Long. $3^{\circ} 37' 6''$.

The ore in this neighbourhood occurs as a replacement of impure limestone at or near the bottom of the Basement-Beds of the Carboniferous, overlying Silurian Shales. The Basement-Beds consist of at least 500 ft. of red conglomerates, sandstones and shales, with some lenticular bands, up to 10 ft. in thickness, of bastard limestone (cornstone) near the base.³ According to the six-inch Geological Map the Ty'n-y-caeau iron-mine is situated on the faulted eastern edge of a small outlier or isolated patch of these Basement-Beds.

A large quantity of hæmatite was obtained from the fault prior to 1885, but subsequent workings have shown that the ore-body is not confined to the line of the supposed fault, but that it occurs as an irregular flat, varying from 6 to 14 ft. in thickness, and dipping north-west at 20° to 30° . On the south and south-west the ore-bed appears to thin out against 'shale' or 'slate,' presumably Silurian, and on the west to be cut off by the same rock brought up by a fault.

The ore has been followed down the dip for about 100 yards W.N.W. from the outcrop, and such reserves as there may be appear to lie in that direction, but the extent to which the ore

¹ The information relating to Dingle is supplied by Mr. B. Smith.

² Pen-y-coed on the Old Series One-inch map; not named on the New Series map.

³ A. Strahan and A. O. Walker, *Quart. Journ. Geol. Soc.*, vol. xxxv, 1879, p. 268.

will continue cannot as yet be foreseen. If the fault shown on the Geological Survey Maps is incorrectly placed, the Basement-Beds and any contained ore may also extend eastward and north-eastward of the mine.

A borehole put down early in 1918 at a point 150 yards north-west of the mouth of the slant proved the following Basement-Beds and Silurian rocks; the thicknesses need correcting for a dip of 23°:—

	Ft.	In.
Soft clay	13	0
Red sandstone, fine-grained	4	6
Purple-red sandstones (gritty, and also fine-grained), and fine conglomerates, with beds of cornstone and of crystalline limestone, passing downward ...	87	6
Limestones, brown, purple-grey, and light red; some hæmatite	16	0
Hæmatite and ferruginous limestone	24	0
Purple and green mudstones (Silurian) to	11	8
	156	8

The ore consists of both red and blue ('steel') hæmatite, with some kidney and puddle ore. Some specular ore occurs also. The hæmatite contains a certain percentage of manganese, which about 20 years ago amounted to 8 per cent., but has gradually dropped to about 1·5 or 1·0. The percentage of metallic iron has varied from 30 to 50; phosphorus, ·02 to ·036, occasionally rising to ·04; sulphur (in 1883), ·43 to ·58; and silica, 11·5 to 16·2 and occasionally 20.

A series of 16 analyses made by the Darwen and Mostyn Iron Company, of Mostyn, covering 2,509 tons of the ore, showed the weighted mean percentage of iron to be 39·96, while the manganese varied from 1·23 to 5·2 per cent. Five analyses of smaller-grade ore, covering 675 tons, gave 36·02 as the weighted mean percentage of iron, the manganese varying from 1·4 to 2·37 per cent.

A clean sample of ore taken from the face showed: iron 51, manganese 0·98, phosphorus 0·029, and silica 14·2 per cent.

The following analyses were made by Mr. E. Proctor, of Newcastle-on-Tyne, of ore taken from shallow workings in 1883:—

	Steel or Blue Ore (1)	Steel or Blue Ore (2)	Puddle Ore, soft, red.	Manganese Ore.
Fe ₂ O ₃ ...	65·28	76·57	81·43	—
Fe ...	—	—	—	41·42
Mn ₂ O ₃ ...	—	0·56	—	24·54
Mn ...	1·16	—	—	—
Al ₂ O ₃ ...	1·66	—	—	—
Al ...	—	—	—	17·09
CaCO ₃ ...	5·98	2·50	5·25	—
S ...	0·58	—	—	0·43
P ₂ O ₃ ...	0·09	0·02	trace	—
P ...	—	—	—	0·21
Insol. ...	11·35	19·50	—	14·38
	86·10	99·15	86·68	98·07
Metallic Iron ...	45·70	53·60	57·00	—

The working of ironstone here appears to have begun in 1883, when ore was raised from an open pit. From this the ore has since been followed under the cover of Carboniferous rocks by means of a slant or slope for a distance of 100 yards in a west-north-west direction and to a depth of 80 ft. below the surface. The ore-face in 1913 was 35 to 46 ft. long and 10 ft. high. The ore was brought to the surface in tubs by an inclined tramway.

The hardness of some of the ore necessitated a pressure of 80 lbs. for the air-drills. The water to be dealt with appears to be mainly surface-water. At the time of our visit (3rd August, 1917) the workings, which had been idle since 1913, were flooded, but they have now been unwatered, and the reopening of the mine is under consideration.

The following figures are based on the Home Office Statistics of Output:—

Year.	Tons raised.	Percentage of Iron.	Value in £.	Value per Ton.
1883	... 328	—	—	—
1884	... 133	—	—	—
1909	... 250	50	125	10s. 0d.
1910	... 432	43	259	12s. 0d.
1911	... 2,333	42	1,209	10s. 4d.
1912	... 1,793	40	540	6s. 0d.
1913	... 657	40	248	7s. 6d.

In 1909 the mine was taken over by the Bell Metal Mining Company, Limited, but was abandoned in 1913, partly through difficulties of transport. The bulk of the ore went to the Darwen and Mostyn Iron Company, Mostyn.

For much of the above information we are indebted to Mr. J. D. Wilkinson, of Messrs. G. W. Wilkinson, Mining Engineers, Whitehaven, and to Messrs. Jaeger Brothers.

NANT-UCHAF MINE

Messrs. Jaeger Brothers, 8, Union Court, Old Broad Street, E.C. 2

Shafts¹ situated 400 yards north-east of Nant-uchaf, 1½ miles south-west of Abergelle (Fig. 3, p. 24). Nearest railway-station: Abergelle and Pensarn (L. and N.W.), 2½ miles by road.

One-inch New Ser. Ordnance Map, 95; Old Ser. Geological, 79 S.W.; six-inch Geological, Denbighshire 4 S.E. Lat. 53° 16' 10". Long. 3° 35' 52".

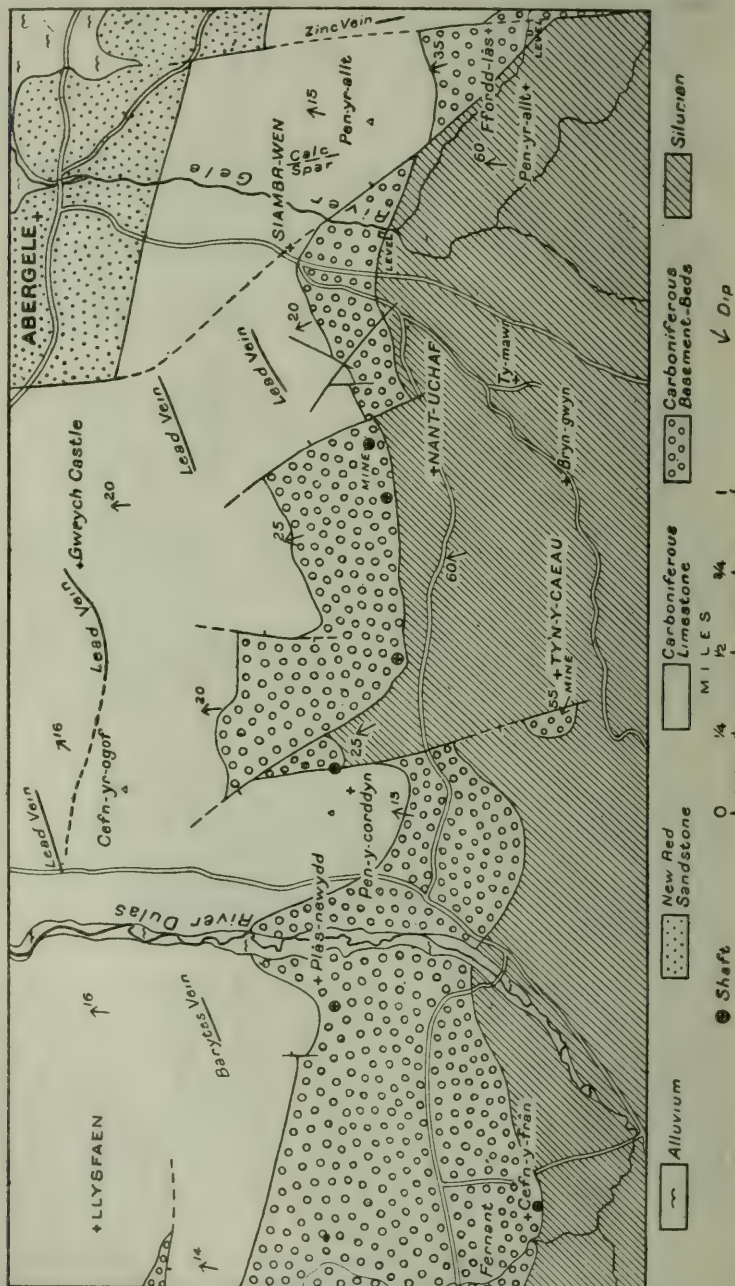
The ore occurs as a flat or bed near the bottom of the Carboniferous Basement-Beds. According to the six-inch geological map these dip N.N.W. at 35°. The ore-bed, which is overlain by thick-bedded hard brown grit and red gritty limestone, and is separated from the Silurian shales and flags below by a 4-inch band of dark-red sandstone, varies in thickness from 5 to 20 ft. It consists of two layers: an upper band of carbonate and black oxide of manganese,² with an average thickness of 2 ft. (varying from 7 in. to 7 ft., with occasional pockets up to 8 ft. thick),

¹ See also De Rance. *Trans. Manchester Geol. Soc.*, vol. xvii (1882-4), p. 47, and *Coll. Guard.*, vol. xlv. 1882, p. 895. Also 'Geol. of Rhyl, Abergelle, and Colwyn' (*Mem. Geol. Surv.*), 1885, pp. 55, 56.

² 'Special Reports on Mineral Resources' (*Mem. Geol. Surv.*), vol. i, Tungsten and Manganese Ores, ed. 2, 1916, p. 54.

and a lower band of red hæmatite, which varies in thickness (inversely as the manganese-band) between 5 ft. and 20 ft. This compound ore-bed follows the dip of the country-rock, and any reserves would presumably lie to the north-west.

FIG. 3.—Map of Iron-mining District, Abergele, Denbighshire.



The hæmatite appears to have been discovered about the year 1872, and Nant-uchaf is first mentioned in the Mineral Statistics

in 1874; it is absent in 1876-79, and finally disappears after 1883. The ore was won by shafts. Some of the deeper of these had been abandoned by 1882. At that period three were being used by the Abergele Hæmatite Company; No. 1, to the rise, being 45 ft. deep; No. 2 (the engine-shaft), 80 yards away to the deep, being 108 ft. in depth; while No. 3, 60 yards farther to the deep, was 126 ft. A boring, carried down for 45 ft. into the Silurian rocks, found no ore in them.

In following the dipway from No. 1 to No. 3 shaft, hæmatite was worked for a distance of about 200 yards from No. 1. In the shallower part of the mine, down to a depth of 90 ft., the ore-body is said to have been 30 to 45 ft. in width; beyond this, down to 40 yards depth, it narrowed down to 24 ft., and the manganese-bed grew thin. In one part of the mine the ore-body had a width of 75 ft.

The working of hæmatite appears to have proceeded for several years before the value of the associated manganese-ore was recognised by Mr. H. J. Wright, now of Llanbedr, Merioneth, to whom we are indebted for particulars. The mine was abandoned in 1883 on the price of hæmatite falling to 10s. 3d. per ton. In March, 1918, the reopening of the mine was under consideration, and a boring now (July, 1918) in progress has reached a depth of 99 ft.

The following outputs are taken from the Mineral Statistics and Home Office Returns:—

Year.		Tons.	Year.		Tons.
1874 ...	...	2,053	1881 ...	...	358
1875 ...	...	2,242	1882 ...	...	1,171
1880 ...	...	624	1883 ...	...	200

The ore is designated 'brown hæmatite' in 1874 and 1875; 'hæmatite' in 1880 and 1881; 'red hæmatite' in 1882 and 1883. In 1882 the average percentage of metallic iron is given as 45.

OTHER TRIALS NEAR ABERGELE

On the western bank of the Gele near Siambr-wen, on the Llanrwst road 6 furlongs south of Abergele, a drift was made in the Carboniferous Basement-Beds, and in 1880 some 28½ tons of ore were extracted. Several other trial-shafts and levels between Colwyn and Dinorben, marked on the six-inch Geological Map, Denbigh 4, are shown on Fig. 3, p. 24.

DERBYSHIRE

Hæmatite has been worked in the Carboniferous Limestone of this county in a few places. It occurs in fissures in the limestone¹ in much the same manner as in the Barrow district, and also in pockets within a few feet of the surface, from which it is gathered by the lead-miners. It has been worked by the Sheepbridge Iron Company at Hand Dale, near Hartington, and by the Butterley Iron Company at Fryden Dale, near Newhaven (2½ miles east of Hartington). At Fryden Dale the hæmatite was found at no great depth; but at Hand Dale it

¹ A. H. Stokes, 'Economic Geology of Derbyshire,' Lond., 1878. Also *Trans. Chesterfield Inst. Eng.*, vol. vi, 1878, pp. 60-155.

was won by shafts, in some cases 40 yards deep. Stokes thought that considerable deposits existed near Newhaven, but that the difficulty of transit rendered them commercially unworkable.

The localities concerned fall within Sheet 111 (Buxton) of the New Series one-inch Ordnance map. The Geological Survey Map, Old Series, 81 S.E., published in 1867, shows an ironstone mine at Elton Common, 2 miles W.S.W. of Winster, and another at a place 3 miles E. of Hartington (probably Fryden Dale); also a lode at Narrow Dale, $1\frac{3}{4}$ miles S. of Hartington, another at Gatcham Grange, $2\frac{1}{4}$ miles S.S.W. of that town, and a third three-quarters of a mile west of Winster. The Fryden Dale occurrence is about a quarter of a mile from the Cromford and High Peak Railway. In 1903 a trial for hæmatite was made at Lark Pasture Plantation (now called Alsopmoor Plantation), 3 miles S.E. of Hartington.

The Mineral Statistics for the years 1855 to 1867 mention peroxide of iron in the output of Derbyshire, but do not separate it from the Coal-Measure ores.

According to Farey,¹ hæmatite was formerly found in rounded masses in 'alluvial deposits' near Meesham, Newhaven and Overhaddon, and was used by button-makers. It must be remembered, however, that under alluvial deposits Farey included many superficial deposits other than alluvium. The same writer mentions a mine "south of Newhaven House" in which red iron-ore had been got from the Carboniferous Limestone.

ISLE OF MAN

Veins carrying hæmatite and some spathic ore occur in the Manx Slates (Cambrian?) in the Maughold Head district, in the north-eastern part of the island, and have been mined, particularly between the years 1855 and 1874, during which period they yielded in the aggregate 12,896 tons of hæmatite. The ore took the form of detached bunches, and the mining was never profitable. Judging from the output of the old workings, such reserves as may exist cannot be estimated at more than a few thousand tons.² The workings are described in detail in the Geological Survey Memoir,³ from which the following account is compiled.

In the northern part of the island an area of Carboniferous Limestone, of unknown extent, is buried deeply under Glacial deposits. The conditions of this limestone resemble those of the hæmatite-bearing limestones of Cumberland. The possibility of hæmatite occurring in this part of the Isle of Man has been frequently discussed, but has not been hitherto practically tested by boring.

In all parts of the island spathic ore occurs as a constituent of many of the metalliferous veins; but, as shown by the Mineral Statistics, the amount sold in 11 years (1871-1881) did not exceed 1,886 tons, nearly all of which can be attributed to Foxdale.

¹ 'General View of the Agriculture and Minerals of Derbyshire,' 8vo., Lond., vol. i, 1811, pp. 403, 265.

² 'Summary of Progress for 1917' (*Mem. Geol. Surv.*), 1918, p. 14.

³ 'The Geology of the Isle of Man,' 1903, pp. 125, 291, 539-541.

The hæmatite of the Maughold veins may have been introduced by downward percolation from the New Red rocks, which are known to be present under the Glacial drift in the north of the island and probably at one time extended southward onto the Manx Slates.

The productive hæmatite-veins in the slates are confined to a limited district around Maughold Head, 3 miles south-east of Ramsey. The general course of the veins is north-north-west and south-south-east, and none has been traced for more than half a mile. The Maughold Head Mines¹ include workings at Stack Mooar on the north of the headland, at the Glebe (half a mile farther to the south-east), and at Drynane on the south of the headland. At another locality, $1\frac{1}{2}$ miles south-west of Maughold Head, a north-and-south vein has been worked in the Ballajora Iron Mine,² situated at Margher-e-breck.

The Drynane Mine was active as far back as 1700, and, at a later period, from 1857 to 1874; the Glebe Mine was opened up about 1836; Ballajora flourished between 1858 to 1874, since which time all the mines have fallen into disuse. The reports by Warington W. Smyth during the period 1858-1873 on the Drynane and Ballajora mines show that the discontinuous bunchy occurrence of the ore and the thinning of the veins forbade any prospect of the mines being profitable.

At the Maughold Head Mine, near Stack Mooar, the vein exposed in the cliff strikes in a south-easterly direction and fades north-eastward at 15° from the vertical. It consists mainly of fault-breccia and quartz, with cavities containing hæmatite, and is about 40 ft. wide. An adit was driven from a little above high-water mark for 95 fathoms, but yielded little ore.

The Glebe Mine, worked by a shaft and levels, is said to have proved more productive. The levels were driven north-westward for 212 fathoms and south-eastward for 196 fathoms.

At the Drynane Mine, opened on a different vein, the lode was in places 15 ft. wide, but elsewhere scarcely perceptible. It fades to the east. The hæmatite, which occurred in discontinuous bunches, was won by a day-level, driven in from the cliff and following the vein in a north-north-west direction for 320 fathoms. There was a shaft also. The mine yielded a large quantity of hæmatite between the mouth of the level and the shaft, but little was found farther in.

The Ballajora Mine was opened on a vein coursing north-and-south and fading eastward. The lode, which proved irregular, splitting toward the north into two branches, yielded impure spathic ore and red hæmatite. Some parts of the lode were only 1 to 2 ft. wide; elsewhere it was 2 to 5 ft. wide. The ore was won by shafts.

¹ Six-inch maps 5 S.E. and 8 N.E.

² Six-inch map 8 N.E.

CHAPTER IV

BRISTOL DISTRICT, WEST SOMERSET AND NORTH DEVON

BY T. C. CANTRILL AND R. L. SHERLOCK

BRISTOL DISTRICT

GENERAL ACCOUNT

Red and brown hæmatites have been raised in the Bristol district¹ in past times from the Dolomitic Conglomerate of Triassic age, and also from the Carboniferous Limestone and Coal Measures, but no large deposits have been discovered. It is as impersistent beds in the Dolomitic Conglomerate that the ore is most largely disseminated; but it also forms flats, or fills pockets, faults, and fissures, in the Carboniferous Limestone and Coal Measures wherever now or formerly covered by the Triassic rocks.

In the absence of detailed records it is not in all cases possible to say whether the ore at the following places was found in the Limestone or in the Dolomitic Conglomerate; in some instances it was probably found in both.

In the Dolomitic Conglomerate the ores have been discovered at Westbury; Clifton; St. George's or Easton-in-Gordano; Clapton-in-Gordano; Winford district (6 miles south-west of Bristol); Broadfield Down, near Winford; Chilcompton (3 miles south-west of Radstock); Gurney Slade, near Binegar ($5\frac{1}{2}$ miles south-west of Radstock); Blagdon (8 miles N.N.W. of Wells); East and West Harptree (6 miles north of Wells); Wookey and Higher Pits, near Wells; and Wick, in the Golden Valley (7 miles east of Bristol).

In the Limestone the ores have been found at Ashton Hill and Providence Place or Providence, a mile west of Long Ashton (2 miles south-west of Bristol); Banwell, 5 miles east of Weston-super-Mare; Beacon Batch, a mile south-west of Blagdon; Lamb Bottom, a mile south of Compton Martin (7 miles north of Wells); Broadfield Down; Yatton; Priddy (4 miles N.N.W. of Wells); and Nunney ($2\frac{1}{2}$ miles south-west of Frome).

In the Coal Measures the ore occurs as a vein along a fault in the Pennant Grit at Frampton Cottrell and Iron Acton, and also at Rangeworthy, on the great fault that runs northward from Coalpit Heath to Cromhall, in the northern part of the coalfield. Ores occur also, apparently in similar circumstances, at Temple Cloud, 5 miles W.N.W. of Radstock.

¹ R. Etheridge, *Quart. Journ. Geol. Soc.*, vol. xxvi, 1870, p. 174. J. Anstie, 'The Coal Fields of Gloucestershire and Somersetshire,' 8vo, 1873, pp. 99-101. H. B. Woodward, 'Geology of East Somerset and the Bristol Coal-Fields' (*Mem. Geol. Surv.*), 1876, pp. 165-7. 'Statistics of Output' of Iron Ores (*Geological Survey and Home Office*), annually.

The hæmatite in the Carboniferous Limestone and Coal Measures was presumably formed by infiltration of ferruginous solutions from the Triassic deposits (Dolomitic Conglomerate and Keuper Marl), that in the Dolomitic Conglomerate being due to a concentration of the same solutions at the bottom of the Triassic deposits themselves.

At most of the places mentioned above, the hæmatite has been worked for iron-smelting; but in some cases it has proved to be of no use except for the manufacture of paint, as at Winford. The following table, based on the Mineral Statistics, shows the yield of the separate localities so far as these can be disentangled:—

Output of Hæmatites from 1856 onward (in tons).

Year.	Yatton.	Winford District.	Ashton Hill.	Frampton Cottrell.	Iron Acton.
1856 ...	5,000	1,500	—	—	—
1857 ...	6,000	1,200	—	—	—
1858 ...	707	—	2,000	—	—
1859 ...	1,580	—	750	—	—
1860 ...	569	—	?	—	—
1861 ...	175	—	?	—	—
1862 ...	—	—	?	5,107	—
1863 ...	—	—	?	6,000	100
1864 ...	74	—	?	11,000	250
1865 ...	—	—	620	8,000	100
1866 ...	—	—	635	6,000	50
1867 ...	—	—	—	6,100	—
1868 ...	—	—	—	6,566	—
1869 ...	—	—	626	6,773	—
1870 ...	—	—	2,110	15,249	—
1871 ...	—	—	2,654	8,487	—
1872 ...	—	—	2,000	9,201	—
1873 ...	—	—	15,800	13,682	—
1874 ...	—	—	—	14,842	—
1875 ...	—	1,674	—	8,845	—
1876 ...	—	2,762	—	—	—
1877 ...	—	4,000	—	—	—
1878 ...	—	3,000	—	—	—
1879 ...	—	?	—	—	—
1880 ...	—	1,100	—	—	—
1881 ...	—	3,618	—	—	—
1882 ...	—	4,713	—	—	—
1883 ...	—	4,314	—	—	—
1884 ...	—	3,582	—	—	—
1885 ...	—	2,099	—	—	—
1886 ...	—	4,031	—	—	—
1887 ...	—	1,484	—	—	—
1888 ...	—	1,388	—	—	—
1889 ...	—	1,400	—	—	—
1890 ...	—	636	—	—	—
1891 ...	—	?	—	—	—
1892 ...	—	?	—	—	—
1893 ...	—	?	—	—	—

In addition to the five places given in the table, mines on the Mendip Hills yielded, in 1873, 118 tons, and, in 1874, 57 tons of hæmatite; one of these was probably near the Castle of Comfort,

Priddy, where, according to Anstie, the ore was being successfully worked in 1873, in spite of the distance it had to be carted. In 1880 East and West Harptree yielded 100 tons. Temple Cloud produced some ore in 1875, 186 tons in 1876, and 33 tons in 1877. Wookey yielded 150 tons in 1887. Clifton Crescent produced 3,800 tons and Nunney 800 tons in 1874, and an unspecified quantity in 1875. Wick was productive in 1893, and the Higher Pits (? near Wells) in 1891-3. Lastly, since 1893 sundry openworks and quarries (not specified) have produced 17,862 tons, much of this probably being paint-ore, containing about 34 per cent. of iron, from the Winford district. No hæmatite has been raised in the Bristol District for some years.

There is little doubt that the mining of these ores for iron-making dates back to Roman time. According to Anstie, the chief obstacles to the use of the ores from Frampton Cottrell and Iron Acton were difficulties with the water and the siliceous character of the ore. The latter proved insurmountable in the case of the Winford ore.

The ores were in some cases smelted at the Ashton Vale furnaces near Bristol; some probably went to South Wales.

The Winford Iron Ore and Redding Company's mine being the only one raising iron oxide in 1917, this was visited in August of that year, the details being given below.

DETAILS OF MINES

RED HOUSE MINE, WINFORD

Winford Iron Ore and Redding Company, Limited, Chew Magna, Bristol

Openworks at Heath Hill, three-quarters of a mile S.S.W. of Winford, 6 miles S.W. of Bristol. Nearest railway-stations: Pensford (G.W.R.), 6 miles east by road, and Flax Bourton (G.W.R.), 5 miles N.N.W. by road.

Maps: One-inch New Ser. Ordnance, 264; Old Ser. Geological, 19; six-inch, Somerset 11 S.E. Lat. $51^{\circ} 22' 12''$. Long. $2^{\circ} 40' 10''$.

The ore occurs apparently in the Dolomitic Conglomerate. The mine is worked solely for red and yellow iron oxides (reddle, redding, or ruddle), for use as pigments. The red oxide is, however, accompanied by small masses of hard siliceous hæmatite of a purple-red colour. These are thrown aside and collected into heaps, but not many tons have accumulated although the output of ochre has been going on for years.

An analysis of the hæmatite, made by Dr. Cook, of Clifton, (1st July, 1903), showed 25.21 to 32.4 per cent. of silica, and 2.7 to 12.1 of barium sulphate.

At various times attempts have been made to turn the hæmatite to account for smelting purposes, but owing to its high percentage of silica these attempts have all ended in failure. Under the regime of the Winford Hæmatite Company, about 1872, consignments of the ore were sent to the Ashton Vale furnaces, Bristol, and also to the Westbury furnaces in Wilts, to be smelted with low-grade ores, but without success. About 1882 further experiments were made at Landore, near Swansea, and at Pelsall, in South Staffordshire, with like results. Later still, a syndicate,

prepared to deal with highly siliceous ores, obtained no better results. It is clear, therefore, that as a source of iron-ore the mine is useless, as the quantity thrown out is negligible, even if the quality were satisfactory. The same conclusion doubtless applies to the smaller mines that have till recently raised reddle in the immediate vicinity, none of which has produced any iron-ore for many years.

WEST SOMERSET AND NORTH DEVON

This district includes a few small mines of red hæmatite near Minehead and the more important mines of the Brendon and Eisen Hills, Exmoor, North Molton, Barnstaple and Ilfracombe, which, though yielding in most cases spathic ore in depth, produced brown hæmatite at the surface. Except in the Exmoor and North Molton districts the iron-mining industry is dormant or extinct.

MINEHEAD DISTRICT

ONE-INCH NEW SERIES MAP 278

Red hæmatite was raised many years ago from the Triassic rocks of Porlock, Luccombe (Luckham) and Wootton Courtney, on the coast of the Bristol Channel. It occurs as a concentration in the beds of red ferruginous sandstone and conglomerate. De la Beche¹ describes the ore in these red rocks as being so abundant that it was in some localities quarried, and exported from Minehead and Porlock to the ironworks in South Wales and Monmouthshire.

The openworks were situated both west and east of Luccombe, and at Brockwell (Sheet 294), and are marked on the Old Series Geological Map 20, surveyed in 1834 and revised in 1839. The mine west of Luccombe falls within the six-inch map, Somerset 34 N.W.; that to the east, and the one at Brockwell, within Somerset 34 S.E.

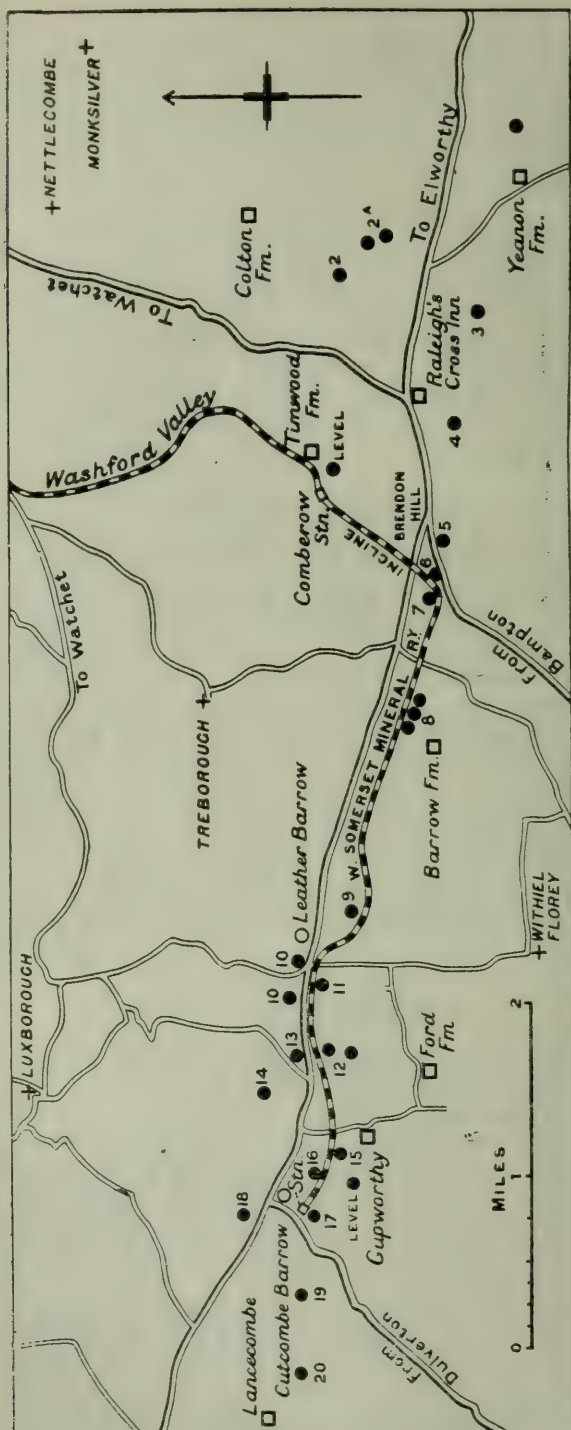
BRENDON HILLS

These hills, which are situated about 6 miles south of Minehead, reach an elevation of from 1,200 to 1,400 ft. above the sea and extend in a direction bearing a little north of west. The crest of the upland is followed by a good road, and until recently was served by a mineral railway from Watchet, the most convenient point of approach. The ironstone-mines, all now abandoned, occur at intervals along the crest of the hills for about 7 miles, from Yeanon Mine in the east to Lancecombe in the west (Fig. 4, p. 32).

They lie in the Old Series one-inch Geological Map, Sheet 20; in the New Series one-inch Ordnance Sheet 294 (Dulverton), and in the six-inch maps Somerset 59 N.W., 58 N.E., 58 N.W., 47 S.W., and 46 S.E.

¹ Report on Geology of Cornwall, Devon, and West Somerset' (*Mem. Geol. Surv.*), 1839, pp. 196-7, 617; also *Mem. Geol. Survey*, vol. i, 1846, p. 264.

FIG. 4.—Map of Iron-mining District, Brendon Hills, Somerset.



The mines are shown by black circles and numbers, farms and buildings by hollow squares, and barrows by hollow circles.

- | | | | | |
|-----------------|--------------------------|-----------------------------|-------------------------|--------------------------|
| 1. Yeaton Mine. | 5. Raleigh's Cross Mine. | 9. Withiel Hill Mine. | 13. Langham Hill Mine. | 17. Gupworthy New Mine. |
| 2. Colton Mine. | 6. Carnarvon Old Mine. | 10. Loathbrook Mine. | 14. Bearland Wood Mine. | 18. Kennisham Hill Mine. |
| 3. Roman Mine. | 7. Carnarvon New Mine. | 11. Betsey Mine. | 15. Baker's Mine. | 19. California Mine. |
| 4. Carew Mine. | 8. Barrow Farm Mine. | 12. Smallcombe Bottom Mine. | 16. Gupworthy Old Mine. | 20. Lancecombe Mine. |

Geological Conditions

The mines have been described in considerable detail by Morgans and others,¹ from whose papers the following particulars are mainly compiled. The country-rock consists of Devonian shales and sandstones more or less affected by slaty cleavage, the colours being red, yellow, and pale-green. The slate associated with the lodes is usually blue or green. Several bands of limestone are shown on the Geological Survey Map, and a few dips are marked, generally in a southward direction, along the mining district. The angle of dip is said by Morgans to be 30° or 40°. The cleavage is recorded by the same writer as dipping S. by W. at 40°-80°. On the Survey Map (published in 1834) the occurrence of ironstone is not indicated, except that, west of the Brendon Hills, at Eisen Hill (N. of Winsford), the symbol for iron-ore is engraved.

The ore is not a stratified deposit, but is contained in true fissure-veins which, closely following the strike of the cleavage of the country-rock, range E. 10° S. and W. 10° N., and dip towards S. 10° W. at 50°-70°. There is reason to believe that there is more than one vein; for while some of the mines fall into line as if on one vein, others are out of line, and are presumably situated on parallel or branch veins. These branches may unite and continue as a single vein.

The main veins extend for several miles, but for the greater part of the distance are barren. The ore is contained in productive pockets, which vary from a few yards to 100 fathoms in length and from a few inches to nearly 30 ft. in thickness. In the case of Raleigh's Cross Mine two lodes aggregated 27 ft. in thickness. In places the pockets are close together; elsewhere they are more than a mile apart; in all cases they are connected by a vein-track of soft clay-slate, quartz and threads of ore. The depth to which the pockets descend from the surface has not been ascertained. Collins records that in 1873 Gupworthy Old Mine had reached a depth of 1,000 ft.

The ore in depth appears to consist of chalybite (FeCO_3) containing a large proportion of manganese, presumably as *dialogite* (MnCO_3); but near and at the surface it has been converted into *manganiferous limonite* and *hæmatite*, with which *göthite*, *psilomelane* and *manganite* are associated. Quartz forms a layer on the footwall. Commercially, the ore was raised as 'white ore,' i.e. *spathic*, generally crystalline, and 'red ore,' i.e. the decomposed *spathic*. Intermediate varieties were known as 'brown ore,' 'black ore' and 'potty ore'; these were dark brown and generally more or less cellular. In regard to grade of size, some of the ore was known as 'rocky,' the rest being

¹ Morgan Morgans, 'The Brendon Hills Spathose Iron Ore, and Mines.' *Trans. South Wales Inst. Eng.*, vol. vi, 1868-9, pp. 78-122.

Warington W. Smyth, 'On the Iron-Ores of Exmoor.' *Quart. Journ. Geol. Soc.*, vol. xv, 1859, pp. 105-9.

J. H. Collins, 'Observations on the West of England Mining Region,' 8vo, Plymouth, 1912, pp. 270-272, 423.

Morgan Morgans, 'On a Peculiarity of the Brendon Hills Spathose-Iron Ore veins.' *Quart. Journ. Geol. Soc.*, vol. xxv, 1869, pp. 255-6.

'sandy.' The specific gravity¹ of the red ore varied from 3.72 to 4.45; that of the white ore from 3.61 to 3.74.

The following analysis of a sample of spathic ore from the Brendon Hills was published by Percy² in 1864:—

Protoxide of iron	...	...	...	...	...	43.84
Sesquioxide of iron	...	...	...	...	...	0.81
Protoxide of manganese	...	...	...	...	...	12.64
Lime	...	...	...	...	...	0.28
Magnesia	...	...	...	...	...	3.63
Carbonic acid	...	...	...	...	...	38.86
Water	...	...	...	...	...	0.18
Ignited insol. residue	...	...	...	...	...	0.08
						<hr/> 100.32 <hr/>
Iron, metallic	...	...	...	...	...	34.67

According to Smyth³ this sample was obtained from Goosemoor.

There is little doubt that the ores of the Brendon Hills were worked by the Romans, whose coins have been found in some of the workings. Large beds of slag show that at some time the ore was smelted locally with charcoal, and at several of the mines, *e.g.* at Colton, Raleigh's Cross, Roman, Carew, Barrow Farm, Withiel Hill, Smallcombe Bottom, and Kennisham Hill, ancient shallow workings on the veins have been discovered, some of which may be of mediæval date.

The modern period of activity opened about the year 1851. According to Morgans the presence of specimens of minerals among the old crop-workings led a Mr. Tibbets, a Cornishman, to drive an adit at Gupworthy for copper. The adit failed to prove copper, but cut a lode of pure undecomposed spathic iron-ore at 20 fathoms. Specimens from Gupworthy comparing favourably with some Continental spathic ores that were exhibited at the Exhibition of 1851, the discovery was brought to the notice of the Ebbw Vale Company, who at once commenced working the mine.

Collins gives a different account. According to him spathic ore was found about 1848 at Raleigh's Cross by a Mr. Blackwell, and it was this discovery that led to the Ebbw Vale Company taking up the matter. Development rapidly followed, and most of the mines were opened up between 1854 and 1867. After being abandoned by the Ebbw Vale Company about 1883, a recent attempt to reopen the mines was made by the Somerset Minerals Syndicate, Limited, about 1908, under a Mr. Smith, whose activities were mainly directed to the driving of a deep level from the head of the Washford Valley at Timwood southward towards the old Carew Mine near Raleigh's Cross. Begun in 1909, it was hoped that this level would intersect the lodes formerly worked at Colton; but nothing of importance having been struck, the work was abandoned after having reached a length of about 530 yards. About the same time several of the old mines were reopened, the Yeanton Mine by a Mr. Raymond Byrne in

¹ Morgans, *op. cit.*

² John Percy, 'Metallurgy: Iron and Steel,' 8vo, London, 1864, pp. 210, 227.

³ *Quart. Journ. Geol. Soc.*, vol. xv, 1859, pp. 105, 108.

1907, and the Colton mine by Mr. Smith, but they were soon abandoned.

The ore was won generally by slants or slopes, which more or less closely followed the lode downwards from the surface. From the slopes levels were driven eastwards and westwards in the lode at various depths. The ore was pulled up in tubs on rails, and water was raised by pumps. In several cases day-levels, driven cross-measure, were used to reach the ore, as at Colton and Bearland Wood. The chief obstacles to a large output were the occasional serious development of quartz, the dissemination of quartz in the ore, and the lenticular character of the veins.

The Mineral Statistics of the Geological Survey up to 1881, and their continuation by the Home Office to the present day, give the outputs of ore from the Brendon Hills and Eisen Hill jointly, as below:—

Output of the Brendon Hills and Eisen Hill.

Year.	Tons.	Year.	Tons.
1855	4,940*	1871	27,556
1856	7,620*	1872	27,913
1857	9,642	1873	28,982
1858	19,018	1874	38,316
1859	23,183	1875	41,792
1860	18,072	1876	41,351
1861	23,787	1877	46,894
1862	29,321	1878	40,115
1863	32,209	1879	14,100
1864	36,385	1880	27,668
1865	27,541	1881	26,265
1866	29,468	1882	31,354
1867	32,524	1883	10,081
1868	27,925		
1869	23,458	1908	2,550
1870	14,603	1909	920
		Total	765,553

* Including Exmoor.

The output for 1908 was produced by the Somerset Minerals Syndicate, Limited, and the ore is said to have contained 55 per cent. of iron. The ore raised in 1909 was produced from the Colton Mine by the Watchet Briquetting Syndicate, Limited, and contained 44·2 per cent. of iron.

The value of the 27,668 tons of ore raised from the Brendon Hills mines in 1880 was £22,134 8s., or 16s. a ton.

The lenticular and impersistent character of the lodes renders any estimate of reserves a matter of great uncertainty. Morgans, writing in 1868, after 9 years' experience in developing the mines under the Ebbw Vale Company, estimated that 12 million tons of good clean ore were procurable within a depth of 300 fathoms below the surface. Deducting the subsequent output (443,918 tons for 1869 to 1909, inclusive) as given in the Mineral Statistics, we have about 11½ million tons as reserve.

The ore was transported by the West Somerset Mineral Railway to Watchet Harbour for shipment to Newport, its destination being the Ebbw Vale Company's works at Ebbw Vale, Mon. The line was partly made about 1855 to deal with the group of mines at Brendon Hill (Raleigh's Cross and Carnarvon), and in 1864

was extended to Gupworthy to relieve the more westerly mines. Until a few years ago a passenger service was run; but in September, 1917, the line was being dismantled.

Notes on the Mines

In the following notes the mines are mentioned in order from east to west, and are numbered as in Fig. 4, p. 32. Most of them are shown on the six-inch Ordnance Maps. The authority for most of the mining details is the invaluable paper read by Morgans in 1868, and already quoted.

1. *Yeanon or Elworthy Mine*.—Three furlongs east of Yeanon Farm. Six-inch Somerset 59 N.W. Lat. $51^{\circ} 5' 31''$. Long. $3^{\circ} 20' 6''$.

A slant, with an air-shaft 120 yards west of it. Not mentioned by Morgans in 1868. Referred to (under the name Halworthy) by Collins, in 1873, as at work and as 100 ft. deep.¹ The ore was carted to the top of the Comberow incline for 2s. 9d. a ton. After having been long closed the slant was cleaned out to a depth of 180 ft. by Raymond Byrne about 1907, but nothing further was done. The slant is now filled in.

2. *Colton Mine*.—About half a mile S.S.W. of Colton Farm. Six-inch Somerset 58 N.E. Level: Lat. $51^{\circ} 6' 25''$; Long. $3^{\circ} 21' 24''$. Main shaft: Lat. $51^{\circ} 6' 17''$; Long. $3^{\circ} 21' 7''$.

A day-level, driven E. 30° S. from the brook-side in Galloping Bottom, with a main shaft (the Colton Pit) 500 yards to the south-east on higher ground. There is also an air-shaft. The level passed the main shaft at a depth of 180 ft., the shaft itself being deeper. Smith reopened the level and worked it for about 3 years (1907-10), raising about 2,000 tons of ore, of which a consignment of 400 tons was sent to furnaces at Maryport with satisfactory results. The level yields much water. The vein is said to be double. The upper lode, which is separated from the lower by a few feet of country-rock, is soft and of inferior quality to the lower lode, which is blue and massive.

In Smith's time the ore was pulled up from the level-mouth to the higher ground on the south by an inclined plane, and conveyed thence to the top of the Comberow incline at Brendon Hill by a narrow-gauge railway laid alongside the main road.

The Colton mine described by Morgans in 1868 appears to have been situated in another combe, 600 yards to the south-east (in the six-inch Ordnance Sheet, Somerset 59 N.W.), where ancient open workings, over 500 yards in length, had long been known (2a on Fig. 4, p. 32). About 1865 the Ebbw Vale Company drove several day-levels from the brook-side south-westward and cut the lode at the bottom of the old workings, about 100 ft. below the surface. No. 1 level followed the lode for $5\frac{1}{2}$ chains north-westward and found both 'hard' and 'soft' ore.

The veins worked at Colton lie three-quarters of a mile north of that worked at Yeanon, and are presumably different, unless that vein has been thrown out of course by folding or by faulting.

3. *Roman Mine*.—At the head of Tripp Bottom, about 1,100 yards S.E. of Raleigh's Cross Inn. Somerset 58 N.E. Approximate Lat. $51^{\circ} 5' 43''$. Long. $3^{\circ} 21' 40''$.

¹ Unless otherwise stated, the depths are vertical depths and are not measured down the slant or slope, which would give a larger figure.

There were some small ancient workings here, but modern mining had only recently been begun when Morgans wrote in 1868. He records that the ore had been traced in the bed of a stream.

4. *Carew Mine*.—About 450 yards S.W. of Raleigh's Cross Inn. Somerset 58 N.E. Lat. $51^{\circ} 5' 52''$. Long. $3^{\circ} 22' 35''$.

There were some ancient workings here. The mine was reopened a little prior to 1868, but Collins found it idle in 1873. Smith intended his deep level from Timwood (p. 34) to cut this slope.

5. *Raleigh's Cross Mine*.—At the hamlet of Brendon Hill. Adjacent to the south side of the Bampton Road at the seventh milestone from Watchet. Called also Laurence Cross Mine. Somerset 58 N.E. Lat. $51^{\circ} 5' 55''$. Long. $3^{\circ} 23' 30''$.

This was one of the first mines to be worked by the Ebbw Vale Company, and has been opened up to a greater extent than the others. In 1858 the slope, which descends at an angle of 50° from the horizontal, had reached a vertical depth of 94 ft. from the surface. By 1867 it had reached a vertical depth of 381 ft. with 17 levels. Collins gives its depth in 1873 as 800 ft. In this mine the lode divided into several branches, two of which near No. 10 levels aggregated 27 ft. in thickness and consisted entirely of brown 'potty' ore. The red ore found at the surface gradually changed at a depth into dark-brown potty ore with gōthite, which in turn became subordinate to white ore below 140 ft. from the surface. Smyth gives 2 to 20 ft. as the thickness of the lode, and 45° as its dip, increasing in the western part of the mine to 65° . In the footwall a quartz-rib 3 to 6 ft. thick entirely excludes the ore in places.

6. *Carnarvon Old Mine*.—At Brendon Hill. About 300 yards west of Raleigh's Cross Mine, and a few yards east of the top of the railway incline. Somerset 58 N.E. Lat. $51^{\circ} 5' 55''$. Long. $3^{\circ} 23' 48''$.

This mine is connected by a heading with Raleigh's Cross Mine. It appears to have been abandoned in 1866 on the opening of the Carnarvon New Mine. Collins found it idle in 1873.

7. *Carnarvon New Mine*.—At Brendon Hill. About 250 yards west of the Carnarvon Old Mine, and a little west of the railway incline. Somerset 58 N.E. Lat. $51^{\circ} 5' 56''$. Long. $3^{\circ} 23' 58''$.

A slope, still open, going in S. 10° W. at 60° , and said by Collins to be 400 ft. deep. Red and yellow shales are exposed at the mouth. The workings were connected with Carnarvon Old Mine and Raleigh's Cross by the heading mentioned above. The slope appears to have been commenced in 1866 and the lode proved to be very thick. Cavities in the potty ore enclosed masses of white ore weighing from 1 cwt. to 2 or 3 tons.

8. *Barrow Farm Mine*.—About 300 yards N.E. of Barrow (Burrow) Farm. Somerset 58 N.E. Lat. $51^{\circ} 6' 2''$. Long. $3^{\circ} 24' 59''$.

A slope (filled in), ancient crop works, and an engine-house and chimney mark the site. The slope is said to be 150 ft. deep. Apparently the mine was disused by the time Morgans wrote in 1868. There are indications of two other slopes a little farther east. The lode on reaching this place from the Carnarvon

mines bifurcated, its thickness at the fork being 18 ft. The ore was hard, and red and blue in colour.

9. *Withiel Hill Mine*.—Presumably the same as Florey Hill Mine. About 550 yards S.E. of Leather Barrow. Somerset 58 N.W. Lat. $51^{\circ} 6' 20''$. Long. $3^{\circ} 26' 28''$.

Opened as a slope by Morgans about 1867. There were ancient workings about 30 ft. deep, below which the ore was found to be generally very hard and red, but some was soft and contained hard concretions of bluish ore. Apparently idle in 1873.

Immediately south of Leather Barrow, Morgans's maps show a string of ancient openworks about 600 yards long on a vein—here apparently ranging 350 yards north of, and parallel to, that worked at the Withiel Hill Mine. Farther west, also, the Loathbrook, Langham Hill, Bearland Wood and Kennisham Hill mines, ranged along the vein worked at Leather Barrow, lie 400 to 600 yards north of, and parallel to, those worked at Smallcombe Bottom, Gupworthy and California. This may be a development of the bifurcation noticed at Barrow Farm.

10. *Loathbrook Mine*.—On the north of the main road, near its junction with the branch road to Luxborough. There was a slope in the north-eastern angle between these roads, and a level 350 yards W.N.W. of the junction. Somerset 47 S.W. Slope: Lat. $51^{\circ} 6' 32''$; Long. $3^{\circ} 26' 53''$. Level: Lat. $51^{\circ} 6' 36''$; Long. $3^{\circ} 27' 8''$.

Said by Collins to be 300 ft. deep in 1873.

11. *Betsey Mine*.—A slope 170 yards west of Withiel Bridge (on the railway), $1\frac{1}{4}$ miles N. of Withiel Florey. Somerset 58 N.W. Lat. $51^{\circ} 6' 29''$. Long. $3^{\circ} 27' 2''$.

12. *Smallcombe (Smoky) Bottom Mine*.—About half a mile N. by E. of Ford Farm. There was a slope, and a level 170 yards S. by W. of the slope. Somerset 58 N.W. Slope: Lat. $51^{\circ} 6' 25''$; Long. $3^{\circ} 27' 34''$. Level: Lat. $51^{\circ} 6' 20''$; Long. $3^{\circ} 27' 36''$.

Said locally to have been overpowered by water. Shown on Morgans's map, but not mentioned by Collins. The lode, which was thin, was worked to a slight depth by the level and slope, and was afterwards reached by a cross-measure drift from the Bearland Wood No. 2 adit. It yielded soft red ore.

13. *Langham Hill Mine*.—On the north side of the main road, about 1,000 yards west of the branch-road to Luxborough. Called also the Bearland Wood Engine-drift. Somerset 47 S.W. Lat. $51^{\circ} 6' 36''$. Long. $3^{\circ} 27' 40''$.

A slope 480 ft. deep (measured along the slope) and inclined at 52° from the horizontal. Begun in January, 1866, to reach the deeper ore previously worked by No. 2 Bearland Wood (p. 39). The Langham Hill slope thus commanded an extensive range of the two lodes (Leather Barrow and Florey Hill) and linked up the workings at Bearland Wood, Loathbrook and Smallcombe Bottom. The upper part of the slope is in dead ground, the ore not having been struck till a depth of 260 ft. was reached. White and red ores were worked.

14. *Bearland Wood Mine*.—In the wooded valley (Chargot Wood) between Langham Hill and Kennisham Hill. Somerset 47 S.W. Approximate Lat. $51^{\circ} 6' 45''$. Long. $3^{\circ} 27' 56''$.

Apparently two cross-measure drifts, close together, were carried from the valley to intersect the lode. No. 1 (on the west) worked the lode and was carried beyond it for exploration purposes, but stopped in 1864. Several strings of ore up to 6 in. thick were cut. A branch adit was carried cross-measure towards Gupworthy to drain the lode worked there.

No. 2 (on the east) was begun 45 ft. lower than No. 1, and intersected the lode previously worked by No. 1; from it headings driven eastwards in the vein proved it to be good, over 12,000 tons of soft red ore being raised. Subsequently the Langham Hill slope (p. 38) was sunk to win the ore at greater depths than could be reached by No. 2 drift.

15. *Baker's Mine*.—A slant adjacent to the south side of the railway, 780 yards east of Gupworthy Station on the Dulverton branch road, at the end of the mineral railway. The mine is 350 yards N.N.W. of Gupworthy Farm. Somerset 58 N.W. Lat. $51^{\circ} 6' 23''$. Long. $3^{\circ} 28' 25''$.

16. *Gupworthy Old Mine*.—Adjacent to the north side of the railway, 480 yards east of Gupworthy Station. Somerset 58 N.W. Lat. $51^{\circ} 6' 26''$. Long. $3^{\circ} 28' 35''$.

Opened about the middle of the 19th century, and apparently one of the earliest of the local spathic mines. The ore was won by a slant inclined at 70° from the horizontal. In 1873 the depth was 1,000 ft. A considerable portion of the lode was 20 ft. thick and large quantities of white ore were raised from it by the Ebbw Vale Company. Westwards the lode split, and in the southern branch soft red, potty, and white ore were all found. Small quantities of copper pyrites were occasionally observed in this mine. There was also a level (Gupworthy Level) by the brook-side 300 yards south of the slope.

17. *Gupworthy New Mine*.—Situated about 420 yards west of the old mine, and 150 yards south of Gupworthy Station. Somerset 58 N.W. Lat. $51^{\circ} 6' 28''$. Long. $3^{\circ} 28' 54''$.

Said by Collins to be 300 ft. deep in 1873. There were old crop-works on a lode (called by Morgans the Cutcombe Barrow lode) intermediate in position between that at Gupworthy and that at Kennisham Hill. The lode runs between Cutcombe Barrow and the main road, and Morgans's map indicates that, west of the Dulverton road, trial-pits sunk on this lode in Goosemoor Plantation by the B.H.I.O. Company [Barrow Hæmatite Iron Ore Company?] found ore $2\frac{1}{2}$ ft. thick at 15 ft. depth.

18. *Kennisham Hill Mine*.—At Kennisham Hill, about 200 yds. N.W. of the junction of the main road with the Dulverton road. Somerset 47 S.W. Lat. $51^{\circ} 6' 50''$. Long. $3^{\circ} 28' 54''$.

Anciently the lode was worked on the crop at intervals for about a mile. In the operations of the Ebbw Vale Company the ore was won by three drifts, none of which went far below the surface. An old engine-house and chimney still survive at the western end of the workings, where the debris on the tips contains small fragments of green copper ore. The nockets of iron-ore ran unusually straight, and yielded only red and brown ores, which were much mixed with softened killas. This fact and the

soft condition of the walls proved detrimental to the mine. The main lode is said to have been 16 ft. thick.

19. *California Mine*.—Apparently on the same vein as that worked at Gupworthy. The mine is not shown on Morgans's plan, but a vein is indicated at 'Higher Goosemoor,' and the mine may be identical with one referred to by Morgans and known locally as the Goosemoor Mine. About 800 yards west of Gupworthy Station. Somerset 46 S.E. Lat. $51^{\circ} 6' 33''$. Long. $3^{\circ} 29' 33''$.

The mine, which had not been far developed in Morgans's time, yielded soft, clean, red ore. According to the same authority, no ore of any importance had been found west of this on the Brendon Hills.

20. *Lancecombe or Lanescombe Mine*.—Mentioned by Collins as 200 ft. deep in 1873. Probably a trial-shaft shown on Somerset 46 S.E., 800 yards west of the California Mine and 550 yards south-east of the site of Lancecombe cottage. Lat. $51^{\circ} 6' 33''$. Long. $3^{\circ} 30' 10''$.

EISEN HILL

Some 3 miles west of the mines on the Brendon Hills, and forming a link between them and the Exmoor mines, lies the group of disused workings at Eisen Hill,¹ a mile north of the village of Winsford. The hill rises to a height of 1,161 ft., between the River Quarme on the east and Larcombe Brook (a tributary of the Exe) on the west, and lies midway between Dunster and Dulverton.

On Morgans's plan ancient crop-workings are shown about 500 yards in length, ranging westward across the hill and ending on the west at the road to Winsford [from Aldworthy]. The only sources of information appear to be the works of Smyth (1859), Morgans (1868), and Collins (1912), already cited (p. 33).

The workings extend westward at intervals for 1,300 yards up Eisen Hill from the side of the River Quarme at Honeywell to a little beyond the summit, where they end, a little beyond Ison Lane, at a point midway between Aldworthy and East Nurcott Farms. The ground falls within the New Series one-inch Ordnance Map 294 (Dulverton), and in Sheet 20 of the Geological Survey Map, surveyed in 1834 and partly revised in 1839. The six-inch maps concerned are Somerset 46 S.E. and S.W., on which the old mine and its shafts are shown. Poorsland Level: Lat. $51^{\circ} 7' 18''$. Long. $3^{\circ} 33' 2''$. Holecombe Levels: Lat. $51^{\circ} 7' 22''$. Long. $3^{\circ} 33' 26''$.

The geological conditions and the characters of the veins are much the same as at the Brendon Hills, the veins worked at Eisen Hill being the westward continuation of those worked at Kennisham Hill (p. 39). According to Smyth, the lodes range W. by N. and E. by S., and dip southwards at 60° . They are, however, lenticular in places, being pinched up to a few inches and then rapidly opening out to 8 ft. in thickness.

¹ Spelt 'Eyeson' on the Ordnance map of 1809; not named on the one-inch New Series Map (Sheet 294) of 1894. Spelt 'Ison' on the six-inch maps of 1903-4, and 'Eisen' by Morgans and by Collins. It is tempting to accept Smyth's suggestion that the latter spelling is correct, and derives from the activities of some immigrant miners of German origin *temp. Eliz.*

The veins yielded excellent brown ore of the variety called pitchy ore (*eisenpecherz*), with some crystalline limonite, psilomelane and manganite. Little white ore was found.

The first exploitation, according to Morgans, was by shallow crop-works, and it was presumably these which led to the presence of iron-ore being indicated at this spot on the Geological Survey Map of 1834-9. Later there were levels known as the Office Levels, which by 1868 had been long abandoned. The Hoecombe or Holecombe Levels (Nos. 1 and 2) opened high up on the eastern side of the hill, and not far under the ancient workings, and had won some valuable pockets before 1868. Poorland Level (Ison Iron Mine of the six-inch map) entered the eastern foot of the hill by the side of the Quarne, and 294 ft. lower than Hoecombe No. 2, with the purpose of intersecting the lodes at a greater depth. The lode proving to be more productive, the workings were connected, and much ore raised, mainly of the potty brown variety.

EXMOOR DISTRICT

About 4 miles west of Eisen Hill the Exmoor district begins with some old workings near Withypool on the River Barle. The veins are apparently the westward extension of those worked on the Eisen and Brendon Hills. The only source of information respecting these lodes is the paper, published in 1859, by Smyth,¹ who speaks of the exploration of the veins as having received much attention during the previous seven years, *i.e.* 1852-8, about the time that the mines on the Brendon Hills were being opened up. Some of the old mines are shown on the six-inch Ordnance maps. The most easterly of the workings appear to be those of the mine at Higher Blackland or Halsgrove, a mile north-west of Withypool. As this mine seems to have been active at a later period than some of the others, it was visited on 6th September, 1917, and is described below.

HIGHER BLACKLAND MINE, WITHYPOOL

Shaft and adit on Higher Blackland Farm, a mile N.W. of Withypool, 6 miles N.W. of Dulverton. Nearest railway-station: East Anstey (G.W.R., Devon and Somerset Branch), about 8 miles S.S.E. by road.

One-inch New Series Ordnance Map, 294 (Dulverton); Old Series Geological, 20; six-inch Somerset 45 S.E. Lat. $51^{\circ} 7' 8''$. Long. $3^{\circ} 39' 22''$.

The ore occurs in Devonian rocks presumably in a similar manner to that of the Brendon Hills (p. 33). The adit is driven westward from the side of the Pennycombe Water for about 200 yards to a shaft sunk on higher ground. According to local information the mine, which is sometimes known as the Halsgrove Mine, was working over 30 years ago, and at one time was owned by the Exford Iron Ore Company. It was abandoned through the competition with Spanish hæmatite.

The falling-in of the shaft has blocked the adit. At the time of our visit (September, 1917) the old dump contained several hundred tons of ore.

¹ 'On the Iron-ores of Exmoor.' *Quart. Journ. Geol. Soc.*, vol. xv, 1859, pp. 105-109.

Other places and mines where iron-ore has been raised in the Exmoor district are as follows; most of them lie between Withypool and Simonsbath:—

ONE-INCH NEW SERIES MAP 294 (DULVERTON)

An old unnamed iron-mine, with shaft and adit, two-thirds of a mile S.W. of Newland ($1\frac{1}{2}$ miles W. of Exford). Marked on Somerset 45 S.E. Lat. $51^{\circ} 7' 28''$. Long. $3^{\circ} 41' 8''$.

Little Woolcombe.—Possibly Woolcombe Farm, 3 miles W.S.W. of Withypool. Somerset 56 N.W. According to Smyth, hæmatite was obtained here from near the surface of some veins. It exhibited small crystals of specular ore, but had the structure of spathic.

Honeymead.—Probably the farm so named, $3\frac{1}{2}$ miles W. by N. of Exford and $1\frac{1}{2}$ miles E. of Simonsbath. Somerset 45 N.W. Lat. $51^{\circ} 8' 46''$. Long. $3^{\circ} 42' 10''$. Sold 500 tons of spathic ore in 1858 for £250. The six-inch map shows an old quarry and air-shaft about a mile north-east of Honeymead Farm, and these may represent the mine.

Exford.—A mine of this name, the site of which we have been unable to ascertain, raised 3,000 tons of spathic ore in 1874, but sold only 10 tons. In 1877 it had 1,000 tons of brown hæmatite in stock. Said by Collins to have been still working in 1879.

ONE-INCH NEW SERIES MAP 293 (BARNSTAPLE)

Huel Eliza.—Situated on the south bank of the River Barle, a mile S.E. of Simonsbath. Somerset 45 S.W. Lat. $51^{\circ} 7' 42''$. Long. $3^{\circ} 44' 12''$. According to Smyth, the lode was worked some time prior to 1858 for copper-ore, but presented at depth a mass of sparry iron-ore with small disseminated portions of copper pyrites.

The Deerpark, Simonsbath.—Situated a mile S.W. of Simonsbath. Somerset 44 S.E., on which several old iron-mines and old shafts are marked. Some of these were later known as the Exmoor Mine in 1910-13 (*see below*). Smyth records that numerous parallel lodes here yielded at the surface a large proportion of hæmatite, particularly in the case of Rogers's lode. The main portion of their contents was brown or hydrous peroxide in a state of great purity, but having the general rhombohedral structure of the spathic (carbonate) ore. The composition of the ore of Rogers's lode as analysed by Mr. Riley, of Dowlais, was as follows:—

Peroxide of iron	...	...	...	...	...	71.34
Peroxide of manganese	...	...	...	...	...	16.79
Silica	...	...	...	...	...	1.49
Alumina	...	...	...	...	...	1.10
Lime	...	...	...	...	...	0.13
Magnesia	...	...	...	...	...	0.22
Phosphoric acid	...	...	...	...	...	0.33
Combined water	...	...	...	...	...	7.98
Moisture	...	...	...	...	...	0.79
Oxides of nickel and cobalt	...	...	...	...	...	0.19
Oxide of copper	...	...	...	...	...	0.05
						<hr/> 100.41
[Iron, metallic	...	...	...	...	...	49.938]

Rogers's lode was 2 to 13 ft. thick, averaging probably 9 ft. It consisted of loosely agglomerated g \ddot{o} thite with occasional bands of quartz and fragments of country-rock.

Exmoor Mine.—Near Blue Gate, at the western end of the Deepark, a mile south-west of Simonsbath. Somerset 44 S.E. Lat. about 51° 7' 34"; Long. about 3° 46' 12". Probably one of the old mines east of the main road and marked on the six-inch map, with other openings on Burcomb, west of the road. In 1910-13 the mine raised 1,700 tons of ore containing 55 to 56 per cent. of iron.

Hangley Cleave.—Situated 2 miles south-west of Simonsbath, on Somerset 44 S.E., on which an old iron-mine is shown. Smyth records that here a vein, 15 to 20 ft. thick, of botryoidal and cavernous brown ore, intermingled with quartz and slate, is 'succeeded by' [presumably passes downwards into] single nuclei at the depth of a few fathoms, and, still lower, masses of pale compact spathic ore.

Cornham Ford.—On the River Barle, 1½ miles W. by S. of Simonsbath. Somerset 44 S.E., on which an old shaft is marked half a mile south-east of the ford. According to Smyth, the conditions here resemble those at Little Woolcombe, noted above. An analysis, by Mr. Riley, of ore from the Roman Lode, Cornham Ford, is as follows:—

Peroxide of iron	...	...	...	...	...	98.41
Silica	...	...	...	...	...	1.01
Oxide of manganese	...	...	...	...	...	0.29
Magnesia	...	...	...	...	...	0.16
Phosphoric acid	...	...	...	...	...	0.12
Moisture	...	...	...	...	...	0.13
Oxide of copper	...	...	...	...	...	0.04
Nickel and alumina	...	...	...	...	...	trace
						100.16
[Iron, metallic						68.887]

Hoar Oak.—Situated 3 miles north-west of Simonsbath, on Somerset 32 S.E. According to Smyth, the veins here resemble those of the Deepark, noted above.

The output from the Exmoor district is included in the Mineral Statistics of the Geological Survey and Home Office with that of the Brendon Hills for the years 1855 and 1856. In 1857 it was given separately as 15,000 tons of spathic ore. The next mention is in 1874, when Exford is said to have produced 3,000 tons of spathic ore, but to have sold only 10 tons. In 1877 Exford had in stock 1,000 tons of brown hæmatite. Finally, Exmoor Mine in 1910 produced 250 tons of ore containing 56 per cent. of iron; in 1911, 200 tons; in 1912, 400 tons; and in 1913, 850 tons containing 55 per cent. of iron. It has since been idle.

In most of these mines the difficulties of transport would be great, as the nearest railways lie (by road) in some cases 10 miles to the south-west (South Molton Station, G.W.R.) and 9 miles to the west (Blackmoor Station, Lynton and Barnstaple Railway). By these railways the ore could be carried to Barnstaple for shipment. The ore formerly raised was sent to South Wales.

NORTH MOLTON DISTRICT

In the neighbourhood of North Molton, between Dulverton and Barnstaple, several mines have raised ironstone, apparently red and brown hæmatites, with some spathic ore. The country-rock is described by Collins as consisting of nearly vertical brown and claret-coloured slates (Lower Devonian), striking east-and-west. The ore occurs in a copper-bearing belt of veinlets occupying lines of fracture. This metalliferous belt crosses the valley of the Mole about two miles north of North Molton.

ONE-INCH NEW SERIES MAP 294 (DULVERTON)

Molland or Brimley Mine.—Presumably at Brimley or Bremley, half a mile east of Molland, 7 miles west of Dulverton. As this mine lies 6 miles south-east of those on the cupriferous belt mentioned above, it may be situated on a different set of veins. The mine sold 11,735 tons of iron-ore in 1877-1887 for £3,854, in addition to copper-ore.

ONE-INCH NEW SERIES MAP 293 (BARNSTAPLE)

Two copper-mines are shown on the Old Series Geological Map 27 (published in 1835, revised in 1839) between North Heasley and South Radworthy, 2 miles north of North Molton. On the six-inch map, Devon 15 N.W., the following are marked in the neighbourhood of Heasley Mill:—Bampfylde Copper Mine, New Florence Mine, Crowbarn Iron Mine, Stowford Iron Mine, and iron-mines on Bampfylde Hill.

Bampfylde Mine.—This mine sold 7,187 tons of iron-ore for £3,988 in 1873-84, and in 1870 was 110 fathoms deep. Some 1,309 tons of brown hæmatite were sold in 1880 for £785.

Florence Mine.—According to Meade, this mine yielded spathic ore with 55 per cent. of iron, and also hæmatite. The lodes, of which two were worked, dip at 62°, and vary from 4 to 13 ft. in thickness. The spathic ore appears to have had little sale, on account of its needing to be calcined; but at an earlier period (about 1872), when it was worth 20s. a ton, it was raised in some quantity. In 1873 the mine produced 3,000 tons of spathic ore, and in 1874-85 sold 35,386 tons of iron-ore for £26,598.

Stowford Mine.—This yielded 2,382 tons of red and brown hæmatite in 1883-7.

BARNSTAPLE DISTRICT

ONE-INCH NEW SERIES MAP 293 (BARNSTAPLE)

Mines¹ at Shirwell and Bratton Fleming, 5 miles north-east of Barnstaple, produced 40 tons of brown hæmatite in 1873, presumably from lodes in the Devonian Slates. Spraycombe Mine in 1874-76 and 1889 yielded 779 tons of similar ore.

ILFRACOMBE DISTRICT

ONE-INCH NEW SERIES MAP 277 (ILFRACOMBE)

At Combe Martin, on the coast of the Bristol Channel and 4 miles east of Ilfracombe, iron-ores have been worked in the

¹ Meade, *op. cit.*, p. 698.

Devonian Slates. According to Smyth¹ the ore is a bedded deposit, and occurs in the form of small nodules; but as the beds are tilted at a high angle (to the south-south-west), the working of the ore was attended with much difficulty. De la Beche² records, on the authority of Lysons, that between 1796 and 1802 iron-ore to the amount of 9,293 tons was shipped from the lode near Combe Martin to the ironworks at Llanelly. He speaks of the ore as a 'lode.' On the Old Series Geological Map 27 the lode is represented as running east-south-eastward along the southern slope of Hangman Hill, for 2 miles, from the coast at Combe Martin Bay to Holstone Farm. The ironstone raised was brown hæmatite and siliceous spathic ore. The Iron Ore Statistics give the following output: 1855, 1,190 tons of spathic ore; 1856, 400 tons of siliceous carbonate. A mine on the same lode at Challacombe raised 50 tons of brown hæmatite in 1873; another at Girt Down raised 400 tons of similar ore in 1873-4.

¹ 'On the Iron-Ores of Exmoor.' *Quart. Journ. Geol. Soc.*, vol. xv, 1859, p. 105.

² 'Report on Geol. of Cornwall, Devon, and West Somerset' (*Mém. Geol. Surv.*), 1839, pp. 617, 288.

CHAPTER V

SOUTH DEVON AND CORNWALL

BY H. DEWEY

SOUTH DEVON

GENERAL ACCOUNT

The iron-ore production of South Devon is mainly confined to the neighbourhoods of Bovey Tracey and Brixham.

In the Bovey Tracey district a small quantity of magnetite is raised at the Haytor Mine near Ilsington, and some little is derived from the adjacent Smallacombe Mine. At Lustleigh and Hennock the special form of hæmatite known as specular ore has long been raised (Fig. 5, p. 51).

In the Brixham district red and brown hæmatites have been worked at a number of small mines, especially near Sharkham Point (Fig. 6, p. 53).

The earliest mention of the working of these ores appears to be that made in 1839 by De la Beche,¹ who recorded that the iron-ore near Ilsington [probably the magnetite at Haytor] was once raised in considerable quantities, and that the micaceous ores of Dartmoor were sent to London as 'Devonshire Sand' or 'writing-sand.' He mentioned also the occurrence of hæmatite near Brixham.

Magnetite.—This occurs habitually in a massive form, but occasionally good octahedral crystals up to a quarter of an inch in length are found in cavities. The masses are interstratified with the Carboniferous grits and shales (Culm Measures), which have been metamorphosed by the adjacent Dartmoor granite.

Different opinions² have been held as to the mode of origin of the Haytor magnetite. C. Le Neve Foster and J. H. Collins claimed that it was a bedded ore, metamorphosed. D. A. MacAlister suggested pneumatolytic origin as an alternative explanation.

From Haytor and Smallacombe about 30,000 tons of magnetite and hæmatite have been raised. In 1917 the output at the former amounted to some 800 tons, but this is likely to be increased as development proceeds. The reserves at Haytor appear to be

¹ 'Report on the Geology of Cornwall, Devon, and West Somerset' (*Mem. Geol. Surv.*), 1839, pp. 617-8.

² Foster: 'Notes on Haytor Iron Mine,' *Quart. Journ. Geol. Soc.*, vol. xxxi, 1875, p. 628. Collins: 'Observations on the West of England Mining Region,' 8vo, Plymouth, 1912, pp. 25-6. MacAlister: 'Note on the Association of Cassiterite and Specular Iron in the Lodes of Dartmoor,' *Geol. Mag.*, 1909, p. 402; and in 'Geology of Dartmoor' (*Mem. Geol. Surv.*), 1912, pp. 74, 75, 79, 80.

sufficient for many years at the present rate of output. The ore is smelted in the Midlands. Meade mentions that early in the 19th century it was mixed with clay-ironstone from South Wales. The average iron-percentage in the ore raised at that period was about 50.

Specular Ore.—This forms hexagonal plates resembling mica in appearance. It occurs in association with certain minerals generally held to be of pneumatolytic origin, and the country-rock in which the lodes occur at Lustleigh and Hennock is a partly-mineralised granite. Further: as the similar specular ore at Birch Tor and Vitifer (7 miles west of Lustleigh) occurs along with cassiterite, the origin of the specular ore seems to be epigenetic.

The ores occur in the form of narrow lodes, highly inclined or nearly vertical, and coursing practically east-and-west; the thickness of the lodes ranges from a mere film up to 5 ft.

The output from the Kelly and Great Rock mines averages 400 tons a year, and the total amount raised since 1878 from these and neighbouring mines is about 2,500 tons. The ore is used¹ for special classes of work only. Reserves in sight are believed to be sufficient to meet the prospective demand of many years.

The ore was formerly known as 'Devonshire sand' or 'writing-sand' for use as pounce,² and was sent to London extensively, selling at £3 3s. 0d. to £8 8s. 0d. a ton. It is now used in the manufacture of 'non-corrosive' paint for ships' bottoms, and as a lubricant. It is sold to the chemical works in Swansea and Cardiff, and is also exported.

Red and Brown Hæmatites.—These ores are found in the massive earthy state and also as kidney-ore at Sharkham Point near Brixham. They form irregular bodies filling pockets and fissures in the Devonian limestone.

From the group of mines at Sharkham Point the output of hæmatite from 1858 to 1875 was 160,000 tons, and between 1875 and 1915 was still smaller. In 1917 it was approximately 4,000 tons. The reserves, at the present rate of output, appear to be sufficient for some years. Most of the ore is sold for paint-making, but some is used for the manufacture of iron.

Furnaces were erected some time prior to 1880 at Bovey Tracey³ for the reduction of the local ores, but were never put into operation; ore was exported mainly to South Wales, but partly to the North of England.

The analyses below,⁴ published by Meade, show the composition of some of the Devon ironstones:—

¹ J. S. Martin, 'Micaceous Iron Ores, near Bovey Tracey,' *Trans. Manchester Geol. Soc.*, vol. xxiii, 1894-5, p. 162. Several cargoes were, however, shipped to South Wales about 1870 for the iron furnaces.

² R. N. Worth, *Trans. Devon. Assoc.*, vol. vii, 1875, p. 225.

³ R. Meade, 'The Coal and Iron Industries of the United Kingdom,' 8vo, 1882, p. 700.

⁴ *Op. cit.*, pp. 689-695.

Analyses of Devon Ironstones

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
	Magnetite, ? Haytor.	Hæmatite, Smallacombe.	Spathic, Frankmills.	Hæmatite, Brixham.	Hæmatite, Brixham.	Hæmatite, Brixham.	Hæmatite, Brixham.	Paint-ore, Brixham.
Iron peroxide ...	62·20	41·96	—	95·10	69·58	63·42	90·00	89·34
" protoxide ...	16·20	—	—	—	—	—	—	—
" carbonate ...	—	8·48	68·53	—	—	—	—	—
" bisulphide ...	0·07	—	—	—	—	—	—	trace
Manganese peroxide	—	—	—	—	—	—	—	—
" protoxide ...	0·14	—	—	—	—	—	—	0·33
" oxide ...	—	—	—	—	—	0·24	0·30	—
" carbonate ...	—	—	14·40	—	—	—	—	—
Alumina ...	2·28	1·20	—	—	—	—	—	0·33
Lime ...	2·34	1·70	—	—	—	0·60	0·42	0·33
Calcium carbonate...	—	—	6·48	—	—	—	—	—
Magnesia ...	0·37	trace	—	—	—	—	—	0·20
Magnesium carbonate	—	—	7·40	—	—	—	—	—
Silica ...	0·24	10·15	1·20	—	—	—	—	—
Siliceous matter ...	—	—	—	4·15	14·38	35·20	8·60	—
Phosphorus ...	—	—	—	trace	0·10	—	—	—
Phosphoric acid ...	0·10	—	—	—	—	0·28	0·38	0·13
Sulphur ...	—	trace	—	0·12	0·15	—	—	—
Sulphuric acid ...	—	—	—	—	—	—	—	trace
Lead sulphide ...	—	—	1·80	—	—	—	—	—
Oxygen ...	—	17·98	—	—	—	—	—	—
Carbonic acid ...	—	9·09	—	—	—	—	—	—
Organic matter ...	—	—	—	0·49	1·40	—	—	—
Combined water ...	0·34	5·49	—	} 0·14	14·39	—	—	8·83
Moisture ...	0·28	4·83	—		—	—	—	—
Ignited insol. residue	16·26	—	—	—	—	—	—	1·70
Totals ...	100·82	100·88	99·81	100·00	100·00	99·74	99·70	101·19
Metallic iron in raw ore.	57·01	50·44	38·26	66·57	48·70	44·56	63·00	[61·80]
Metallic iron in roasted ore.	—	—	54·70	—	—	—	—	—

I. 'Magnetic oxide of iron, Dartmoor,' believed to be from Haytor. The 'ignited insoluble residue' consists of silica 9·42, alumina 1·53, protoxide of iron 1·12, lime 3·18, magnesia 1·45, potash and soda 0·10; total 16·80. Traces of bismuth, tin, and copper were detected in 900 grains. Anal. Edward Riley, quoted by R. Meade, 'The Coal and Iron Industries of the United Kingdom,' 8vo, 1882, p. 689.

II. Brown hæmatite from Smallacombe. Anal. Mr. Child, Dowlais Ironworks, quoted by Meade (*op. cit.*, p. 691).

III. Spathic ore from Frankmills. The 1·80 per cent. of lead sulphide equals 0·23 of sulphur. Anal. Dr. Noad, quoted by Meade (*op. cit.*, p. 693).

IV and V. Hæmatites from Brixham. Anal. Dr. Odling, quoted by Meade (*op. cit.*, p. 694).

VI. Hæmatite from Brixham. Soft ore in form of fine powder. Siliceous and poor in iron. The 35·2 per cent. of siliceous matter is 'insoluble sand.' Anal. Dr. Noad, quoted by Meade (*op. cit.*, p. 694).

VII. Ditto. Ore in form of lumps, making up seven-eighths of sample. A rich and valuable ore, phosphorus being low and sulphur absent. Anal. Dr. Noad, quoted by Meade (*op. cit.*, p. 694).

VIII. Hæmatite from Brixham, soft and brilliant, used for paint. Meade (*op. cit.*, p. 695).

DETAILS OF MINES

HAYTOR IRON ORE MINES

Ilsington, Newton Abbot

Mr. Reuben Cook, Welsh Mill, Frome

Openworks, adit, and day-level at Haytor Vale, a mile north-west of Ilsington. Railway-stations: Bovey Tracey (G.W.R.), 3 miles eastward by road; Newton Abbot (G.W.R.), 8 miles south-eastward by road.

One-inch New Series Ordnance and Geological Map, 338; Six-inch Devon, 100 S.E. Lat. $50^{\circ} 34' 45''$. Long. $3^{\circ} 44' 5''$.

The 'lode' consists of four distinct bands lying among altered shales and sandstones (Culm Measures).

Foster, in the paper cited, gives a sketch, taken in a new adit-level (at a depth of 20 fathoms below the old openwork), which shows three bands of magnetite, 10 ft., 14 ft., and 6 ft. thick in descending order; but these beds contained seams of waste respectively 2 ft., 1 ft., and 1 ft. thick. According to these figures there would be in all 26 ft. of ore, a figure in excess of that given in an earlier account of the openworks by J. T. Kingston.¹ Perhaps the bands increase in thickness as they are traced downwards.

Recent work in the upper part of the mine has exposed these three bands with a total thickness of $12\frac{1}{2}$ ft. A fourth band, about 3 ft. thick, crops out at a distance of about 300 yds. north-east of the others.²

The bands dip N. 25° E. at 30° , strike E. 25° S., and their outcrops run for about a quarter of a mile in an eastward direction. The footwall of No. 1 lode consists of shale and chert; of No. 2, of a fine-grained aplite dyke; and of No. 3, of black shale. The beds are folded into an anticline, which has been truncated by the intrusive granite-mass at a distance of about half a mile to the north-west of the mine, and has been traced to the south-east for about half a mile.

The ore consists of remarkably pure magnetite, often in octahedral crystals, associated with a mass of actinolite or fibrous hornblende. Other minerals found include quartz, chalcedony, garnet, iron-pyrites, traces of copper-pyrites, arsenical minerals and some spathic iron-ore.

There are no published complete analyses of the ore, but the percentage of iron is said to range from 40 to 70.

An adit 18 fathoms below surface has been driven from Haytor Vale in a S.S.W. direction for 500 yds., and the workings extend underground to a depth of 18 fathoms. There are also some open-cast pits.

From 1858 to 1861, and from 1869 to 1882, a total of 26,500 tons of magnetite, brown hæmatite and micaceous iron-ore were raised from 'Haytor and Ilsington.' In 1908, 1,400 tons of iron-ore containing 57.5 per cent. of iron were produced from the same mine. From 'Haytor Vale' 4,720 tons of magnetite and brown hæmatite were raised in 1866 and 1867, 1872 and 1875.

¹ *Phil. Mag.*, vol. iii, 1828, p. 359.

² 'Geology of Dartmoor' (*Mem. Geol. Surv.*), 1912, pp. 79, 80.

The mine was reopened in 1916, and has since yielded from 60 to 70 tons per month.

SMALLACOMBE IRON MINE

Ilsington, Newton Abbot

Openworks, shafts and adit half a mile south-east of Haytor Vale, and 700 yds. south-east of the Haytor Mine (p. 49).

One-inch New Series Ordnance and Geological Map, 338; Six-inch Devon, 100 S.E. Lat. $50^{\circ} 34' 33''$. Long. $3^{\circ} 43' 40''$.

Limonite and magnetite are present on this property. The limonite occurs in the form of irregular beds of nodules in decomposed shales and grits (Culm Measures), which dip gently to the north-east. The limonite contains 43 per cent. of iron and 4 of manganese.¹

The magnetite forms three or four beds of variable thickness in a thick mass of greenstone, lying below and to the south-west of the beds of limonite. The general dip seems to be about 30° and the strike nearly north-west. The magnetite 'lodes' are presumably the easterly continuation of those at Haytor.²

Umber has been worked in the upper part of the magnetite-lode where decomposed, and contains at a few fathoms from the surface large quantities of garnet rock and hornblende. Collins³ points out that a similar association of minerals is characteristic of magnetite-deposits in Sweden and elsewhere.

An adit was driven in 1872 for a distance of 90 fathoms to intercept the magnetite-beds. There were also three shafts sunk. These are shown in a section of the mine figured in the Geological Survey Memoir already cited.

The mine has recently (June, 1917) been reopened.

Between 1865 and 1873 there were raised 7,952 tons; between 1874 and 1879, 11,770 tons of brown hæmatite, ochre and umber; in 1868, 73 tons of magnetite.

KELLY MINE

Bovey Tracey, Newton Abbot

The Scottish Silvoid Company, Limited, Glasgow

Day-levels and adit situated at Kelly, about half a mile north-east of Lustleigh Church. Station: Lustleigh (G.W.R.).

One-inch New Series Ordnance and Geological Map, 339; Six-inch Devon, 101 N.W. Lat. $50^{\circ} 37' 25''$. Long. $3^{\circ} 42' 9''$.

There are three parallel lodes coursing nearly east-and-west through the granite country-rock, and varying in width from a mere crack up to 4 ft. They hade to the north at 1 in 6.

The country-rock has been mineralised, the felspar having been converted into mica (gilbertite) and the biotite into tourmaline. The ore-body consists of micaceous hæmatite packed together into hard masses and frequently associated with quartz and schorl.

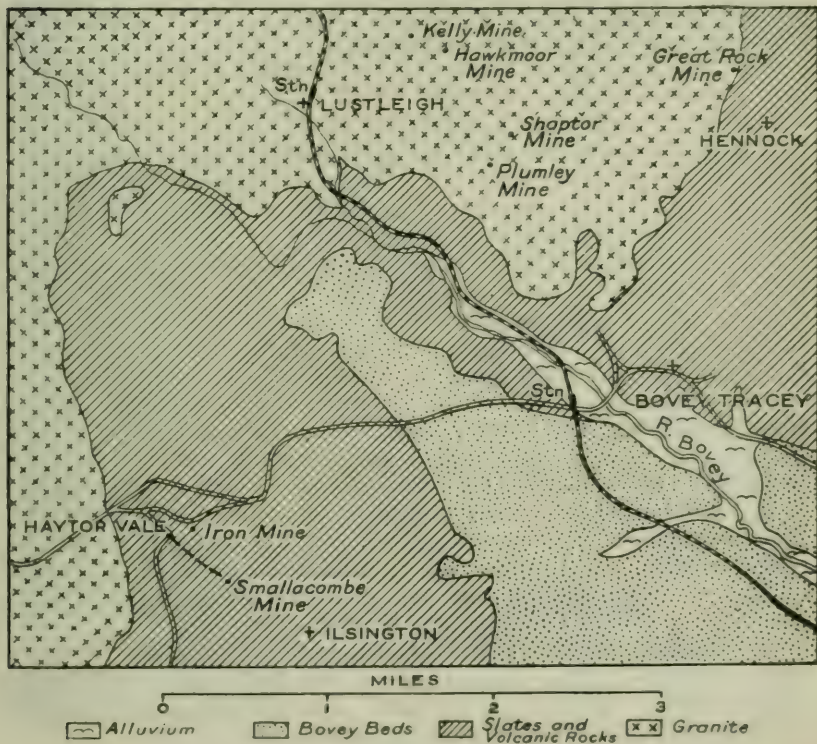
¹ 'Report on Resources of Iron Ores' (Department of Scientific and Industrial Research), 8vo, 1917, p. 15.

² 'Geology of Dartmoor' (*Mem. Geol. Surv.*), 1912, p. 82.

³ 'Rept. Miners' Association, Cornwall,' for 1872-3, p. 71.

Schorl-rock ('kippel' or 'cockle') forms the gangue and is composed sometimes of loosely-aggregated crystals, but more often of hard rock. A characteristic feature of the gangue is the presence of numerous perfectly-formed crystals of marcasite, some over an inch long. So far only a small quantity of cassiterite has been recorded from this area, but it is the main constituent of the 'hæmatite' lodes at Birch Tor and Vitifer on Central Dartmoor. From this evidence the origin of the ore is seen to be epigenetic and pneumatolytic.

FIG. 5.—Map of Iron-mining District, Bovey Tracey, Devon.



The ore is a variety of specular hæmatite, occurring in very fine scales and described as micaceous iron-ore. It has long been worked and was formerly sent in large quantities to London for use as 'writing-sand' or 'Devonshire Sand.' In recent times considerable quantities have been raised under the name of 'shining ore' and exported.

There are three levels above adit, and a cross-cut driven northward into a steep hill. The first level is 8 fathoms, the second 15 fathoms, and the top level about 25 fathoms above the adit. The ore is loaded on to trucks and run to a battery of Cornish stamps worked by an overshot water-wheel, the crushed ore being successively passed under a waterfall, through six sluice-boxes, and into settling-tanks. The micaceous ore is thus separated from the quartz and 'cockle' of the gangue. Water is run off

from the settling-tanks and the ore is taken to the 'drys' and filled into casks ready for transport.

Between 1879 and 1901 the mine yielded 344 tons of brown hæmatite, containing 50 per cent of iron and selling for £3 a ton in 1900. Between 1902 and 1907 the mine produced 794 tons of 'shining ore.'

GREAT ROCK MINE

Hennock, Bovey Tracey

The Ferrubron Manufacturing Company, Hennock, Bovey Tracey

Day-levels and adit situated in Lake's Copse, about three-eighths of a mile N.N.W. of Hennock church. Railway Station: Trusham (G.W.R.), 2 miles eastwards by road.

One-inch New Series Ordnance and Geological Map, 339; Six-inch Devon 101 N.W. Lat. $50^{\circ} 37' 17''$. Long. $3^{\circ} 39' 27''$.

The lode courses in a direction of E. 10° S., underlies at 1 in 5 to the north, and ranges in thickness from $\frac{1}{8}$ in. to 5 ft. Mineralised granite forms the country-rock, in which vast numbers of crystals of marcasite are distributed. The gangue consists of quartz and schorl or 'kippel.'

The ore consists of micaceous hæmatite identical in character with that found at Kelly Mine (p. 50).

There are four levels and several cross-cuts and winzes. The adit-level is 1,500 ft. long; the second level, 100 ft. above, is also 1,500 ft. long; the third, 1,100 ft. long, is 56 ft. above the second; while the fourth is 70 ft. above the third level, 130 ft. from the surface, and 350 ft. long. After passing a set of 4-head Californian prospecting-stamps, the crushed ore is carried in launders to sluice-boxes and settling-tanks. It is dug out of the latter, dried over kilns, and packed in casks in 8-10 cwt. parcels. The water-power is derived from reservoirs working three wheels (400 ft. fall). Compressed air is used for the drills. The ore is sold for the manufacture of non-corrodible paint, and to chemical works at Swansea and Cardiff.

The Great Rock Mine yielded 650 tons of 'shining ore' between 1902 and 1907. The present output for Kelly Mine and Great Rock is about 400 tons per annum. The reserves are considered adequate to last for many years at present rate of output.

SHARKHAM IRON ORE MINE

Brixham

Mr. Reuben Cook, Welsh Mill, Frome

Openworks and adit situated on Sharkham Point, about a mile south-east of Brixham (Fig. 6, p. 53).

One-inch New Series Ordnance and Geological Map, 350; Six-inch Devon 128 N.E. Lat. $50^{\circ} 22' 55''$. Long. $3^{\circ} 30' 7''$.

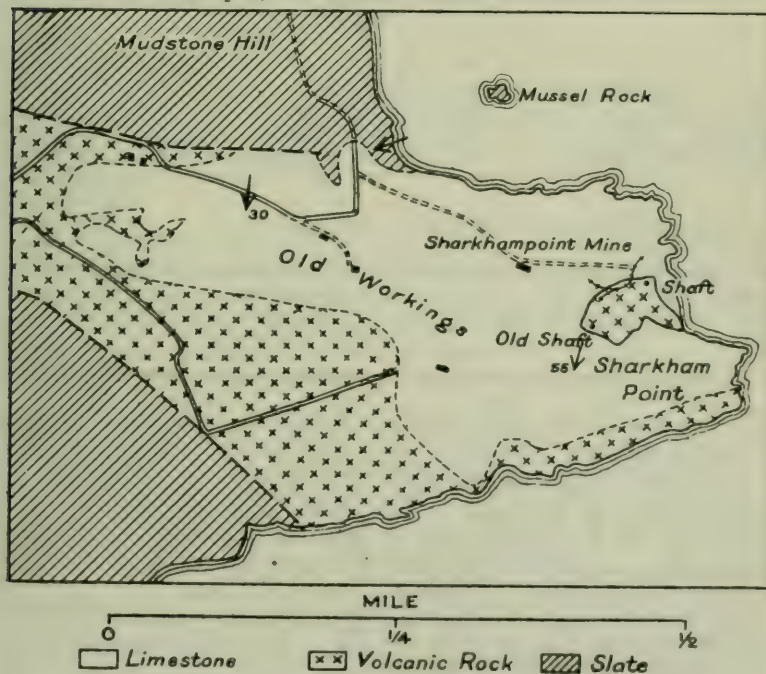
There is no true lode, the ore occurring as irregularly-shaped bodies in Middle Devonian limestone. Some of these bodies occupy pockets or what are apparently old solution-cavities. In these cases the junction between the ironstone and the limestone is sharply defined. More commonly the ore passes gradually into

limestone, and some of the bodies have the appearance of true lodes, with nearly vertical walls. Collins¹ speaks of two 'lodes' at this locality.

The ore consists mainly of red hæmatite, but a small quantity of limonite is met with. The hæmatite is said² to contain, on average, about 53 per cent. of iron, 20 per cent. of silica, 0.01 of phosphorus, 0.03 of sulphur, and 0.1 of manganese. At present the ore is graded into 'firsts' containing up to 60 per cent. of iron, and 'seconds' with 30 per cent. Other analyses, both of furnace-ore and of paint-ore, are given by Meade.

In the mine now being worked the adit, which runs southward, is 400 ft. long, and is connected with a shaft at a depth of 78 fathoms from the surface. There are many levels in the mine, but, as all are above adit-level, no trouble from water is experienced.

FIG. 6.—Map of Sharkham Point, Brixham, Devon.



Iron-ore has been worked in the neighbourhood for many years at the Sharkham, Cloister, Five Acres, Furzeham, Salcombe, Wheal Prosper, Parkin, Upton, Drews and Torbay mines. From this group of mines the output from 1858 to 1875 was 160,000 tons of iron-ore. After 1875 the mines produced very little for some years. The output for 1916 was about 4,000 tons. The present sett includes the whole limestone-area at Sharkham Point,

¹ 'Observations on the West of England Mining Region,' 8vo, 1912, p. 425.

² 'Report on Resources of Iron Ores' (Dept. Scientific and Industrial Research), 1917, p. 15.

and the amount of ore in sight is considered to be large. The ore is sent to ironworks and to paint manufactories.

OTHER SOUTH DEVON MINES

In addition to the active mines described above, a number of others have raised smaller amounts of iron-ore, either as the sole product or as a by-product in the mining of other ores. Some proportion of the output was, however, used for paint, and not for the manufacture of iron. The following notes on some of these mines are compiled mainly from the Geological Survey Memoirs, from J. H. Collins,¹ R. Meade,² and the Statistics of Output:—

ONE-INCH NEW SERIES MAP 338 (DARTMOOR FOREST)

<i>Mine.</i>	<i>Parish.</i>	<i>Six-inch Map (Devon).</i>	<i>Tons.</i>	<i>Mineral.</i>	<i>Period.</i>
Atlas Tin Mine	Ilsington ...	108 N.E.	1,300	Brown hæmatite ...	In 1864.
Birch Tor and Vitifer	North Bovey	99 N.E.	25	Specular ore (58 % iron)	In 1906.
Hatherley Mine	Ilsington ...	—	550	Magnetic ore... ..	In 1866 and 1877.
South Devon United Mine	Petertavy ...	98 S.W.	690	Spathic ore	—
South Devon United Mine	Petertavy ...	98 S.W.	2,150	Brown hæmatite (and umber)	—
South Devon Mine	Buckfastleigh	114 N.W.	1,111	Brown hæmatite and specular ore	In 1872-4.

At the Atlas Tin Mine the brown hæmatite appears to have been obtained from two beds (not lodes) about 55 fathoms apart, the lower bed being associated with iron-pyrites. The beds dip north-eastward at 22° to 27°. The mine (of which a cross-section is given in the Geological Survey Memoir) was worked by shafts and an adit. In 1892 a deep adit (15 fathoms below the shallow adit) was being driven. The country-rock is killas.

At Birch Tor and Vitifer the specular ore was associated in the lodes with tinstone and tourmaline. The lodes trend E. 25° N. to E. 45° N., are more or less vertical, and range up to 2 ft. or more in thickness. The country-rock is granite.

At the South Devon United Mine (Petertavy) the main lode ranges E. 10° S., and appears to be a fault.

At the South Devon Mine near Buckfastleigh (of which the situation is uncertain) Meade records that lodes of brown hæmatite, traversing Devonian killas and limestone, and coursing east-and-west, yielded, in 1872-4, 1,111 tons of ore, which sold at 15s. per ton and contained 55 per cent. of iron. Some of this ore is described as micaceous.

¹ 'The West of England Mining Region,' 8vo, Plymouth, 1912.

² 'The Coal and Iron Industries of the United Kingdom,' 8vo, 1882.

ONE-INCH NEW SERIES MAP 339 (TEIGNMOUTH)

<i>Mine.</i>	<i>Parish.</i>	<i>Six-inch Map (Devon).</i>	<i>Tons.</i>	<i>Mineral.</i>	<i>Period.</i>
Frankmills ...	Christow ...	101 N.W.	240	Brown hæmatite	In 1872, 1879-80.
" ...	" ...	"	182	Spathic ore ...	In 1874-7.
Hawkmoor ...	Bovey Tracey	"	570	Brown hæmatite	In 1892-
Plumley ...	"	"	} 1800	(49%)	1907.
Shaptor ...	"	"			
Shuttamoor ...	Christow ...	91 S.W.		Shining ore.	
South Exmouth	Hennock ...	101 N.W.	181	Shining ore ...	In 1872.
Wolborough ...	Wolborough ?	109 S.E.	124	Brown hæmatite	In 1870, 1874.

The micaceous or shining ore is particularly abundant in the veins in the granite between Lustleigh and Hennock. These veins have a range varying from E. 20° N. to east-and-west, and a width of from 1 to 12 ft. The mines in this area have yielded in recent years about 3,425 tons of shining ore, selling at £4 to £8 8s. a ton.

An important lode of barytic lead, yielding, among other minerals, spathic iron-ore and brown hæmatite in depth, has been worked between Hennock and Christow at the South Exmouth, Frankmills, Adams, Exmouth, Reed, Aller, and Bennah mines. The lode, which traverses the Culm Measures, runs approximately north-and-south, and has been traced for about 2½ miles. It is generally 2 to 4 ft. wide, and in places is vertical or highly inclined to the east. At the South Exmouth Mine (600 yards E. of Hennock) the vein has been worked from shafts to the 90-fathom level, and another vein, parallel and a little farther east, has been proved underground. At the Frankmills Mine (three-quarters of a mile N.E. of Hennock) the lode is branched; the east lode and the west lode have been worked from shafts by cross-cuts and levels to a depth of 145 fathoms (another account says 175). The spathic iron-ore raised at this mine had the composition shown on p. 48, but being merely a by-product of the lead-mining it was not all sold, on account of the cost of transport to Teignmouth. The mine closed down in 1880. At Wheal Exmouth the lode is branched; the workings extend to below the 84-fathom level, and were reached by shafts. The outputs of iron-ore from some of these mines are given above.

Hawkmoor, Plumley and Shaptor mines lie between Lustleigh and Hennock and are named on the 2nd edition (1906) of the six-inch map. The lodes traverse granite, and were worked by levels and shafts. The shining ore from these mines was sold for £4 to £5 a ton. The brown hæmatite raised at Wolborough, on the southern outskirts of Newton Abbot, sold for 10s. to 15s. a ton.

ONE-INCH NEW SERIES MAP 349 (IVYBRIDGE)

<i>Mine.</i>	<i>Parish.</i>	<i>Six-inch map (Devon).</i>	<i>Tons.</i>	<i>Mineral.</i>	<i>Period.</i>
Boringdon Consols	Plympton St. Mary	118 S.W.	680	Iron-ore | ...	In 1852-7.
Bulkamore Iron Mine.	Rattery ...	120 N.E.	4,400	Brown hæmatite	In 1874-5.
Shaugh Iron Mine	Shaugh Prior	118 N.W.	4,670	Iron-ore ...	In 1870-4.
Yealmpton ...	Yealmpton ...	125 S.W.	250	Brown hæmatite	In 1867.
Ugborough ...	—	—	2,233	„ „	In 1874-6.

Boringdon Consols was mainly a lead-mine; the others produced iron-ore alone. Boringdon Consols is situated about 5 furlongs N.W. of Boringdon, and was 62 fathoms deep. The lode runs east-and-west for about a mile from a point in the River Plym about 100 yards south of Plym Bridge. The Shaugh Iron Mine is situated in Square's Wood, 3 furlongs south of Shaugh Bridge. The Bulkamore Iron Mine is situated 3 furlongs N.E. of Bulkamore. The country-rock is in all cases Middle or Upper Devonian slate, the Bulkamore mine being situated at the junction of the slate with a volcanic rock. The ores were mainly limonite or brown hæmatite; that from the Shaugh mine varied in price from 10s. to 15s. a ton, while that from Bulkamore sold for 15s. to 18s.

CORNWALL

GENERAL ACCOUNT

Cornwall has been worked for upwards of two thousand years for its minerals; but although the chief lodes of iron-ore were known certainly as early as 1670, they were apparently not worked until nearly the middle of the 19th century. The occurrence of iron-ore was mentioned by Sir John Pettus in 1670, by Borlase in 1758, and by Camden in 1806, who all remark that the lodes were unworked. But, according to De la Beche¹, by 1839 several iron-mines, among them Restormel, had been in operation for some time. The value of the iron-ore is, however, insignificant in comparison with that of the ores of tin and of copper.

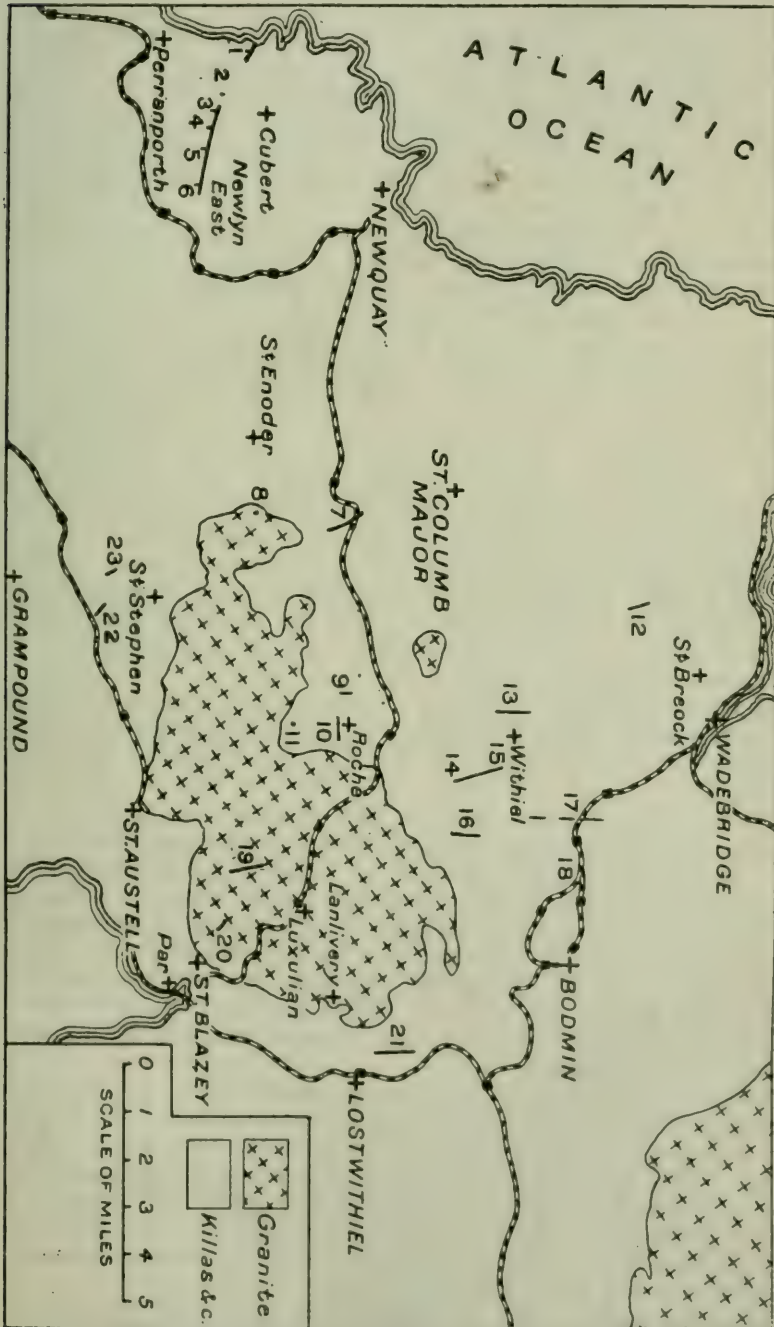
The development of the mines is indicated by the output. Between 1855 and 1865 this fluctuated from 19,000 to 55,000 tons per annum; it fell in 1867 to about 4,600 tons, but rose in 1874 to 45,000, then fell again to a few thousand tons a year. The importation of the cheap Spanish ores led to the closing of Cornish mines. A few, restarting for short periods, have yielded since 1884 about 3,000 tons.

The principal source of iron-ore is the Great Perran Lode, which lies a few miles south of Newquay and extends from the coast inland for a distance of 4 miles (Fig. 7, p. 57). On this lode are

¹ 'Rept. on Geology of Cornwall, Devon, and West Somerset' (*Mem. Geol. Surv.*), 1839, p. 617.

situated the following mines: (1) Gravel Hill, (2) Mount and Trebysken, (3) Treamble, (4) Great Retallack, (5) Duchy Peru, and (6) Deepark.

FIG. 7.—Map of Iron-mining Districts: Newquay, Wadebridge and St. Austell Districts, Cornwall.



Nearly all the other lodes lie around the St. Austell granite-mass and principally between Wadebridge and St. Austell (Fig. 7, p. 57). Upon them from west to east the following mines have been worked: (7) Indian Queen, (8) Wheal Edith, (9) Pits Mingle, (10) Pawton, (11) Tower Consols, (12) Coldvreath, (13) Lanjew, (14) Colbiggan, (15) Retire and Wheal James, (16) Woodley, (17) Nanstallon, (18) Boscarne, (19) Ruby, (20) Treffry, (21) Restormel, (22) Bodinnick, and (23) South Terras. The remaining mines are scattered, but lie mainly in Western Cornwall, between Truro and Helston. The principal are: (24) Wheal Falmouth and Wheal Sperries, and (25) Constantine or Brogden's.

Both the anhydrous oxides of iron: magnetite (Fe_3O_4) and hæmatite (Fe_2O_3), occur in Cornwall. Magnetite forms a constituent of the basic igneous rocks or greenstones and of the lavas, but not generally in sufficient quantity to be worked as an ore. Exceptionally it has become segregated into lenticular beds such as are seen in the cliffs at Botallack near the Land's End, at Trebarwith and Barras Nose near Tintagel, in the greenstone near Treluswell by Penryn, and at South Terras near St. Austell. The black magnetic sand found near Botallack and the ilmenite-sands of Manaccan, in the Lizard district, are derived from similar igneous rocks by weathering. Magnetite occurs also as a lode-filling near Roche church in the St. Austell district.

Under hæmatite are included all the varieties of ferric oxide. Owing to their brilliancy some crystals are called specular iron, iron glance, or looking-glass ore; this ore is worked in Devon, but in Cornwall it has been recorded only at Botallack, and at Restormel near Lostwithiel.

Of massive hæmatite or red iron-ore the principal localities are Restormel, Knightor, Ruby and Treverbryn, all near St. Austell. It occurs also at Tamill, St. Clether, west of Launceston.

The hydrated oxides göthite and limonite both occur in Cornwall. The rare göthite was worked at Restormel, Botallack, and St. Just (Land's End). It sometimes occurs in a characteristic manner as acicular crystals forming fibrous aggregates locally called 'needle iron-ore.' At Restormel a regular succession of iron-ores was found to hold in the vugs or cavities in the veinstone, the sequence being (1) crystalline quartz, (2) fibrous limonite or 'wood iron-ore,' (3) crystalline göthite, (4) compact hæmatite, the successive zones being marked by differences of colour.

Limonite or brown iron-ore, a hydrated oxide of variable composition and of secondary origin, containing about 15 per cent. of water (nearly 5 per cent. more than göthite), is a common ore in Cornwall, and occurs in masses and also in the fibrous form known as 'wood iron-ore,' with radial and zonal structure, and also in stalactitic forms. It has been worked in many of the north-and-south lodes between Bodmin and St. Austell, and in the upper part of the Great Perran Lode.

Chalybite, spathic ore, or siderite, the carbonate of iron, is the principal ore of the Great Perran Lode, and also of the Pawton lode, and is found at many other localities. Near the surface

it has been changed into limonite. Copper pyrites, fluorspar, galena and blende are frequent associates of chalybite, and the assemblage points to their derivation from emanations given off by the granite-masses during consolidation.

Iron-pyrites, although of general occurrence in the Cornish tin-lodes, cannot be regarded as a source of iron-ore; moreover, as it usually contains arsenic, its use in the manufacture of sulphuric acid is attended with difficulties. During the treatment of the mixed concentrates at the tin-mines, the calcination of the iron-pyrites produces finely-divided oxide of iron, which is washed away during the subsequent dressing process and is lost. Experiments have been made to recover it, but the cost has proved too high to render the operation a commercial success.

Nearly all the iron-ore that has been worked in Cornwall occurs in lodes; magnetite, however, probably owes its origin to magmatic concentration, and occurs in less regular bodies. Some veins fill pre-existing fissures; others appear to be zones of rock permeated with metallic minerals. The country-rock is usually slaty killas, but is elsewhere granite, as at the Treverbyn and Ruby mines.

The course of the Cornish lodes is generally north-of-east and south-of-west, and these usually carry tin and copper. But another set of lodes, later than these and known as cross-courses, run in a north-and-south direction. To this series belong most of the iron-ore lodes. The Great Perran Lode, however, follows a general east-and-west course, and for this and other reasons was supposed by W. W. Smyth and J. H. Collins to be the gozzan of a tin and copper lode (p. 62).

Some of the iron-ores may have originated at the time the sediments were deposited; but the majority appear to owe their origin to vapours and solutions given out from the granite-masses during their consolidation from a fluid state. The intimate connection of the iron-ores with minerals that are generally recognized to owe their origin to this cause, the general trend of the lodes, and other phenomena, support this theory.

The reserves of iron-ore at the localities mentioned on pp. 57, 58 are extremely difficult to estimate. The Great Perran Lode is by no means exhausted, and its width, depth and length indicate an enormous quantity of ore if the ore-body is continuous. Working experience, however, has proved its frequent diminution in thickness, its discontinuity, and its local impoverishment. Of the other lodes Restormel is largely stoped away down to adit, and the same remark applies to some of the small lodes lying to the south of Bodmin. A total reserve of 500,000 tons of Cornish iron-ores of all varieties can safely be predicted; a million tons would, perhaps, be a more likely estimate.

Most of the ore was sent to the furnaces in South Wales; some went to the Midlands. Sir Henry Bessemer described the Perran ore as suitable for the manufacture of steel by his process. It has also been used in the basic open-hearth process. The hæmatite from Restormel was in some request for the manufacture of Bessemer pig about the year 1882.

Analyses of some of these Cornish ores are given on pp. 60, 61.

Spathic Ores.

	Duchy Peru.		Treamble.		Pawton.
	I.	II.	III.	IV.	V.
Iron peroxide	—	—	2·00	—	65·00
Iron protoxide	47·43	49·49	—	47·57	—
Iron carbonate	—	—	74·11	—	26·10
Manganous oxide	6·42	7·12	—	7·20	—
Manganese carbonate	—	—	6·73	—	—
Alumina	—	—	—	—	1·80
Lime	0·70	1·56	1·50	—	—
Magnesia	6·03	2·87	7·80	—	—
Silica and silicates	5·04	1·61	8·00	0·64	4·40
Sulphur	0·23	—	nil.	—	0·20
Sulphur trioxide	—	—	—	1·20	—
Phosphorus	trace.	—	nil.	—	trace
Phosphorus pentoxide	—	—	—	trace	—
Moisture	—	—	—	—	1·20
Carbonic acid	33·70	34·67	—	36·76	—
Metallic iron	36·89	38·49	—	37·00	—
Metallic manganese	4·97	5·51	—	5·58	1·00
Phosphorus	trace	trace	—	trace	—
Sulphur	0·23	0·75	—	0·48	—
<i>When roasted :—</i>					
Loss by calcination	31·10	32·74	—	—	—
Metallic iron	53·40	56·60	50·00	—	—
Metallic manganese	7·20	8·10	4·40	—	—

I and II. Rees Price in J. H. Collins's *Rept. Miners' Assoc. of Cornwall and Devon* for 1873, pp. (1-15).

III. Anal. Dr. Noad in J. H. Collins's *Rept. Miners' Assoc. of Cornwall and Devon* for 1873, pp. (1-15).

IV. Anal. Rees Price in J. H. Collins's *Rept. Miners' Assoc. of Cornwall and Devon* for 1873, pp. (1-15).

V. Anal. J. H. Collins in Meade's 'Coal and Iron Industries of the United Kingdom,' p. 706. (Spathic ore from depth of 22 fms).

DETAILS OF MINES

NEWQUAY DISTRICT.

The Perran Iron Lode.—This lode is the principal iron-lode in Cornwall.¹ It courses in a general east-south-easterly direction, which is unusual for Cornish iron-lodes. It also differs in its great thickness, its underlie, and in the nature of its contents from all other iron-lodes in the West of England.

First seen in the cliff-face south of Ligger Point, it can be traced inland for a distance of 4 miles, and with less certainty for several more miles towards the east. The richest section, however, occurs near the west coast and at some localities where

¹ 'Geology of Newquay' (*Mem. Geol. Surv.*), 1906, pp. 100, 101, etc.; also J. H. Collins, 'The West of England Mining Region,' 8vo, Plymouth, 1912, pp. 227-233, and *Trans. R. Geol. Soc. Cornwall*, vol. xiv. Earlier references from which these writers compiled their notes are quoted in the above-mentioned publications.

it has been mined between there and Shepherd's Station. In width it varies from several fathoms to a few inches. A similar diminution occurs also in depth; at one mine the lode died out altogether, but in others it was wide and rich at a depth of 70 fathoms. The underlie varies from 40° to 50° .

The iron-ore at a depth consists of chalybite or spathic ore, but has been converted into oxides and hydroxide of iron for a variable depth down to 20 fathoms. Most of it was brown hydroxide or limonite; but some rich red hæmatite and, more rarely, magnetic ore and pyrites were found.

Associated with the iron-ores are ores of zinc, lead, silver and copper. Especially rich deposits of these ores were found at the point of intersection of the iron-lode with north-and-south courses carrying lead and zinc, some of which contained valuable quantities of silver.

Here and there the lode showed in the mines a somewhat regular sequence of the different ores from the surface downwards. Thus at the Duchy Peru Mine the following sequence was found: for the uppermost 20 fathoms, hæmatite and limonite; in the succeeding 20 fathoms, mainly blende, galena and some copper and silver ores; at the 40-fathom level, an enormous mass of marcasite, which by oxidation gave rise to suffocating gas and high temperatures, resulting in a temporary impeding of the work; and from the 40-fathom to the 70-fathom level (where the working ceased), white spathic ore.

The course of the lode, the association of its ores and their enrichment in depth, suggest that it originated in a similar manner to those of copper and of tin. Most of these also show a regular descending sequence of the constituent minerals, and some of the lead-lodes appear to pass down into copper at depth, while practically all Cornish lodes have their uppermost parts converted into a mass of oxidized mineral-matter known to the miner as 'gozzan.' These facts led both Smyth¹ and Collins² to infer that the Perran Lode is in reality a 'gozzan' or 'iron hat' of a lode bearing copper and lead, possibly of high values, but at a depth of something between 100 to 200 fathoms.

Formerly there was a demand for the ore, but the absence of railway-transport prohibited its being worked. In 1865 a railroad was built, but soon afterwards importation of Spanish ores rendered further working unprofitable. The rails were taken up in 1915, and the question of transport has returned to its position of 1865, except that the track is preserved.

With regard to the quality of the ore Sir Henry Bessemer³ stated that it was especially adapted for the Bessemer process of manufacturing steel, and a Mr. Carter said that on account of the high percentage of manganese in the ore, it was suitable for the manufacture of spiegeleisen.

The reserves of iron-ore in the Perran lode cannot be estimated with any approach to accuracy. Not only does the width of the

¹ *Trans. R. Geol. Soc. Cornwall*, vol. vii, 1858, pp. 332-335, and vol. x, 1882, p. 120.

² *Rept. Miners' Assoc. Corn. and Devon* for 1873 (1874), p. 55.

³ Minutes of Evidence before a Committee of the House of Commons, 1865, Quest. 513-528.

lode vary greatly, but the space between the two walls frequently contains brecciated country-rock, or else the lode itself has suffered great brecciation and cementation by quartz. Smyth¹ remarks that "the statements as to 'practically inexhaustible quantities and the diagrammatic sections showing . . . an illimitable sea of white spathic iron,' require a much closer attention to facts if we would approximate nearer to the whole truth." He then describes the large amount of breccia found in the lode at many localities, and says "in some parts of the lode it is of portentous dimensions, as at the 60 ft. level at the Duchy Mine the lode, 10-12 fathoms in width . . . appears to be one vast mass of this fragmentary material." As regards lateral continuity, he cites several instances where the lode completely died out along the strike.

The downward limit of the iron-ore has never been ascertained. At several mines it was followed to depths varying from 17 to 70 fathoms, but the intervening ground remains unproven.

Similarly with regard to the nature of the ore: the top 20 or 30 fathoms usually consist of a 'gozzan' of either compact or cellular brown hæmatite, sometimes containing unweathered lumps of white chalybite, and often the whole mass is highly siliceous. Beneath the hæmatite the lode appears to be composed of spathose carbonate of iron with occasional bands of blende, some galena and, more rarely, copper. The spathic ore appears to affect the footwall, while the blende occurs in the central and upper parts of the lode.

1. GRAVEL HILL MINE

Perranzabuloe, near Perranporth

(*Reopening*)

The Perran Mining Syndicate, Treamble, Perranporth

Shafts situated on the coast half a mile south-east of Ligger Point, at the north end of Ligger or Perran Bay. Station: Perranporth (G.W.R.), $2\frac{1}{2}$ miles south across the sands, or 6 miles by road.

One-inch New Series Ordnance and Geological Map 346; Six-inch Cornwall 39 S.W. Lat. $50^{\circ} 22' 26''$. Long. $5^{\circ} 8' 42''$.

The mine was formerly known as the Penhale Iron Mine. It was reopened about 1916.

The lode, known as the Great Perran Lode, is visible in the cliff-face, where it is about 100 ft. wide and is divided by a horse of killas. It runs obliquely up the cliff, here 200 ft. high, and fades south-west at 50° at an oblique angle with the cleavage-planes. It includes angular fragments of an elvan that occurs *in situ* a few yards away. The country-rock is Devonian slate.

Near the surface the ore is mainly red and brown hæmatite, but it changes in depth into white spathic ore. The upper part is riddled with veins of white quartz; at the 13-fathom level there was a mass of cellular brown ore about 9 fathoms in width.

¹ The Duchy Peru Lode, Perranzabuloe. *Trans. R. Geol. Soc. Cornwall*, vol. x, 1882, p. 120.

The brown hæmatite contains 49·66 per cent. metallic iron and 5·49 of silica.¹

There are two shafts: No. 1, an air-shaft, a short distance from the edge of the cliff; and No. 2, or Borlase's Shaft, farther inland, which communicates at 15 fathoms with a level to a large excavation, the 'Big Iron Pit,' on the southern branch of the lode. Several other shafts still farther inland were sunk on the lode. From the coast a level was driven in the country-rock of the footwall for a distance of 70 fathoms. The lode was worked to a depth of about 12 fathoms, but below that it rapidly narrowed to 4 ft. and then changed to blue flucan.²

From the cliff-outcrop alone 40,000 tons of ore had been taken out³ by 1873. The Home Office Returns give the output between 1874-1882 as 7,400 tons of hæmatite and 3,000 tons of mixed spathic ore and hæmatite. The hæmatite is quoted as containing 47 per cent. of iron. The possible reserves are discussed on p. 59.

2. MOUNT AND TREBISKEN MINES

Perranzabuloe and Cubert

(Reopening)

The Perran Mining Syndicate

Shafts and day-levels situated at Mount, nearly a mile S.S.W. of Cubert. Station: Perranporth, $2\frac{1}{2}$ miles to the south-west.

One-inch New Series Ordnance and Geological Map 346; Six-inch Cornwall 39 S.W. and 48 N.W. Lat. $50^{\circ} 21' 55''$. Long. $5^{\circ} 7' 15''$.

In width the lode varies from 25 to 50 ft., but the richest ore is confined to the central part, about 3 fathoms wide; nearer the walls it is mixed with quartz and killas. The lode fades S.S.W. at 45° . The country-rock is Devonian slate.

The ore raised was mainly brown hæmatite, the workings having been stopped before they reached the spathic ore. In the western part of the workings blende occurs. The iron-lode is intersected by the Trebisken and Trebellan lodes, which contain sprigs of silver with galena. At about 20 fathoms from the point of intersection with the Trebellan lode a rich deposit of native silver with galena was found. Analyses give the following percentage composition of the hydrated brown iron-ore found at Trebisken: peroxide of iron, 54·28; silica and alumina, 30·8; and water, 14·10.⁴

A level has been driven for a distance of 320 yds. from the north and then turns parallel to the lode, with several cross-cuts, proving it for a distance of some 200 fathoms. The lode has been worked to a depth of about 10 fathoms.

¹ W. R. Roebuck, 'Observations on the Iron Mines of Cornwall,' 8vo (published privately), 1876.

² N. Bryant, *Rept. R. Cornwall Poly. Soc.*, 1870. pp. 98-100.

³ J. H. Collins, *Rept. Miners' Assoc. for Cornwall and Devon for 1873*, p. (3).

⁴ J. T. Woodhouse, *Journ. Iron and Steel Inst.*, vol. ii, 1871, p. 32.

Mount and Trebicken yielded 32,600 tons of hæmatite between 1859 and 1876; in addition, Mount Mine, between 1871 and 1874, produced 3,700 tons of hæmatite. The mine was reopened in 1916.

3. TREAMBLE MINE

Perranzabuloe, near Perranporth.

(*Reopening*)

The Perran Mining Syndicate

Shafts and openworks at Treamble, a mile south of Cubert. Station: Perranporth, $2\frac{1}{2}$ miles to the south-west.

One-inch New Series Ordnance and Geological Map 346; Six-inch Cornwall 48 N.W. Tennant's Shaft: Lat. $50^{\circ} 21' 39''$. Long. $5^{\circ} 6' 49''$.

The Perran iron-lode¹ is here 6 fathoms wide and dips W.S.W. at about 40° . The country-rock is Devonian slate. The ore is of inferior quality at the surface, but improves in depth. It consists of red hæmatite, kidney-ore, and brown hæmatite, down to a depth of about 17 fathoms, below which the white spathic ore is found; this ore continues in depth. For analyses, see pp. 60, 61.

There are two great open excavations. In the western one the iron-lode was proved by an underlie shaft to a depth of 17 fathoms and was worked to below drainage-level. In the eastern quarry the lode splits into several branches and has been proved to a depth of 17 fathoms by another shaft (Berryman's Shaft, near Great Retallack).

A lead-lode belonging to the Retallack Mine crosses the iron-lode and at the junction galena was proved to a depth of 7 or 8 fathoms. This lead contained horn silver and native silver.

The output between 1859 and 1892 amounted to 15,300 tons of hæmatite. In addition there were 958 tons of brown hæmatite and spathic ore. Some of the brown hæmatite raised in 1892 contained 43 per cent. of iron. The mine has recently (1917) been reopened.

There may be large reserves, as the mine is only 700 yds. from Mount Mine and scarcely any of the lode between the two properties has been touched.

4. GREAT RETALLACK MINE

Perranzabuloe

(*Reopening*)

The Perran Mining Syndicate

Shaft situated about two-thirds of a mile west of Rejerrah.

One-inch New Series Ordnance and Geological Sheet 346; Six-inch Cornwall 48 N.E. Berryman's Shaft: Lat. $50^{\circ} 21' 38''$. Long. $5^{\circ} 6' 31''$.

In this sett the lode² generally is several fathoms in width and at the 60-fathom level is said to be 240 ft. wide, but it is doubtful

¹ J. H. Collins, 'The West of England Mining Region,' pp. 229-230.

² Collins, *op. cit.*, pp. 229, 230.

if this measurement was taken at right-angles to the lode. The country-rock is Devonian slate. The lode courses about south-east, and underlies south-west. Near the surface it contained brown hæmatite and blende, the latter ore increasing in depth. According to W. R. Roebuck¹ the brown hæmatite contains about 56 per cent. of metallic iron and 1·2 of silica. Below the 60-fathom level copper ore occurred. In the mine, at Stephens's Shaft, a great mass of hornblende rock was met with in sinking, while near its intersection with the Peru lode the iron-ore contained rich argentiferous galena.

Berryman's Shaft was sunk to a depth of 17 fathoms.

Between 1850-1880, 10,850 tons of hæmatite were produced and $1\frac{1}{2}$ tons of very rich silver-lead ore. The mine was reopened in 1917.

5. DUCHY PERU MINE

Perranzabuloe

(Idle)

The Perran Mining Syndicate

Shafts situated at Rejerrah. Station: Perranporth, 3 miles south-west, or Goonhavern Halt, $1\frac{2}{3}$ miles south.

One-inch New Series Ordnance and Geological Map 346; Six-inch Cornwall 48 N.E. Roebuck's Shaft: Lat. $50^{\circ} 21' 30''$. Long. $5^{\circ} 5' 59''$.

At this locality the Great Perran Lode² changes its course from E. 30° S. to E. 10° S.; it underlies south at 40° . The lode averaged about 70 ft. in width, of which perhaps 25 ft. bore iron-ore, and persisted in depth locally to at least 80 fathoms. The country-rock is Devonian slate.

The ore for a depth of 20 fathoms consisted of brown hæmatite, below which was found a quantity of blende in irregular masses up to 40 ft. in width; galena also occurred. These ores were mainly in the middle of the lode-cavity, while the iron-ore affected the footwall. At a depth of 40 fathoms there were large masses of marcassite, which by oxidation gave rise to such heat that work was retarded, and in consequence of which the level was known as the 'hot end.' From the 50-fathom down to the 80-fathom level the lode yielded only chalybite or spathic ore; but below the 60-fathom it consisted mainly of breccia, 10 to 12 fathoms wide, composed of slate fragments, quartz and some blende. Sir Henry Bessemer visited the mine and stated that the ore was entirely suited for his process of manufacturing basic steel. The composition of the ores is given on pp. 60, 61.

The distribution of the ore, however, varied in different parts of the workings. The rich course of spathic ore, which held down almost vertically to 70 fathoms and was 6 to 9 ft. wide at the Main Shaft, came to an end suddenly both eastward and westward. Again: west of Hathorne's Shaft, another column of chalybite extended for only a few feet laterally and was succeeded by a quartz-filling of the nature of a cross-course, with

¹ 'Observations on the Iron Mines of the Great Perran Lode' (privately printed), 1876, p. 20.

² Collins, *op. cit.*, pp. 230, 231.

impressions of crystals of fluorspar. Another product of the lode is zinc-blende, which was found as huge masses up to a ton in weight, and amounted to as much as 900 tons a month.

In estimating reserves the impersistent character of the lode, both laterally and in depth, must be borne in mind. Much of the fissure carried only slate-breccia, and the adjacent killas forming the country-rock was much disturbed. Such conditions are likely to recur along the lode.

The extent of ground worked out and the total output are both unknown, but it is not likely that the levels met those of adjacent mines, so that there may be considerable reserves. According to Collins, in the period 1858 to 1886 the mine yielded 21,400 tons of brown hæmatite, 11,000 of chalybite, 180 of ochre and umber, and 760 of iron pyrites.

The 'back' of the lode was worked by opencast pits; the deeper parts by shafts, levels, cross-cuts and winzes. The Main Shaft was 80 fathoms deep when the mine was abandoned in 1886. There appear to have been at least four other shafts, the more important being Roebuck's (70 fathoms deep in 1881) and Vallance's. These two shafts are connected by cross-cuts at the 40 and the 50-fathom levels. Sea-level is at 40 fathoms below the surface, and adit at about 150 ft. In June, 1917, the mine was flooded.

6. DEERPARK MINE

Newlyn East

(Disused)

Shafts and openworks situated about half a mile south-east of Rejerrah and nearly a mile north-west of Shepherd's Station (G.W.R.).

One-inch New Series Ordnance and Geological Map 346; Six-inch Cornwall 48 N.E. Barton's Shaft: Lat. $50^{\circ} 21' 26''$. Long. $5^{\circ} 4' 56''$.

The Perran iron-lode traverses this sett and is crossed by three or more lead-lodes, but very little work has been done.¹ The country-rock is Devonian slate. From 1875-9, 267 tons of iron-ore, 3 tons of lead-ore, and 10 tons of blende were sold.

WADEBRIDGE AND ST. AUSTELL DISTRICT

This district contains a number of scattered mines on veins that traverse the St. Austell granite and the killas surrounding it.

7. INDIAN QUEEN MINE

St. Columb Major

(Abandoned)

Indian Queen Mining and Colour Company, Limited

Openworks and shaft at Toldish, $2\frac{1}{2}$ miles south of St. Columb Major. Station: St. Columb Road, $1\frac{1}{2}$ miles south-west by road.

¹ J. H. Collins, *op. cit.*, p. 467.

One-inch New Series Ordnance and Geological Map 347; Six-inch Cornwall 40 N.E. Shaft: Lat. $50^{\circ} 24' 6''$. Long. $4^{\circ} 55' 22''$.

The main lode, known as the Gaverigan lode, has been worked by opencast pits.¹ Its bearing is N. 33° W., and it can be traced from the Bodmin and Truro main road at Toldish north-westward across the disused tunnel on the Newquay branch railway at the Indian Queen Colour Works towards Treliver, where it bears N. 50° W. In the tunnel it was found to contain 16 to 18 ft. of clean iron-ore.

The ore is limonite, with some red hæmatite and pockets of wad and solid black oxide of manganese. The mine was worked largely for ochre and umber. The country-rock is Devonian slate metamorphosed.

The lode was worked by open quarries for a depth of about 40 ft.; day-levels were then driven along the lode. There were several shafts also. The hæmatite was used in the manufacture of paint, and although there is a considerable quantity of ore left, this residue is said to be too impure for that purpose.

The output from this lode was contributed by several different mines: Toldish, Indian Queen, and Ruthvoes or Ruthers, which last appears to be identical with Indian Queen. From Indian Queen 17,847 tons of iron-ore were raised in 1856-1863 and in 1876; from Ruthvoes, 1,242 tons in 1872 and 1,022 tons of manganese ore in 1874-5, 1880-1; there were also yields of ochre and umber. Toldish seems to have been worked for manganese as early as 1754.

Treliver Lodes.—Some old openworks and shafts in the fields immediately south of Treliver² (three-quarters of a mile N.N.W. of Toldish) were worked for iron-ore on several lodes, some of which run east-and-west, others north-and-south. Treliver raised 1,380 tons of iron-ore (mainly hæmatite) in 1858-61.

8. WHEAL EDITH

St. Enoder

(Disused)

Shafts situated at Retew, 4 miles S. by E. of St. Columb Major. Station: St. Columb Road (G.W.R.), 2 miles north-westward by road.

One-inch New Series Ordnance and Geological Map 347; Six-inch Cornwall 40 S.E. Lat. $50^{\circ} 22' 35''$. Long. $4^{\circ} 55' 32''$.

An old report states that there are three lodes in the sett. No. 1 has not been worked, but its outcrop is exposed in a china-clay pit. No. 2 has been worked to a depth of 10 fathoms for a distance of 40 fathoms, but the workings are now filled in. No. 3 has been worked to a depth of 6 fathoms for a distance of 30 fathoms. The ore was red and brown hæmatite,³ and the country-rock is granite.

Nothing is recorded as to output, and reserves are unknown.

¹ 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 158.

² *Ibid.*, p. 158.

³ *Ibid.*, p. 144.

The mine is within half a mile of a mineral line (the Retew Branch) connected at St. Dennis Junction with the Par and Newquay Branch of the G.W.R.

9. PITS MINGLE IRON MINE

Roche

(Disused)

Openworks, known as Dyehouse Mine and as Trerank¹ Mine, situated at Pits Mingle, about half a mile west of Roche. Station: Roche (G.W.R.) $1\frac{1}{2}$ miles.

One-inch New Series Ordnance and Geological Map 347; Six-inch Cornwall 41 N.W. Lat. $50^{\circ} 24' 15''$. Long. $4^{\circ} 50' 34''$.

The lode runs north-and-south. The only record relating to this mine is that 344 tons of iron-ore were sold in 1858, and that between 1866 to 1868, 1,173 tons were sold. The ore was hard siliceous limonite. The country-rock is calcareous Devonian slate metamorphosed.

10. TOWER CONSOLS

Roche

(Disused)

Shaft known also as Wheal Click and as 'The Magnetic Iron Mine,' situated a few yards to the south of Roche church. Station: Roche (G.W.R.), a mile north.

One-inch New Series Ordnance and Geological Map 347; Six-inch Cornwall 41 N.E. Lat. $50^{\circ} 24' 9''$. Long. $4^{\circ} 49' 50''$.

The lode runs east-and-west (parallel with the strike of the killas), is nearly vertical, and consists principally of magnetic iron-ore with some red hæmatite and limonite. Collins² states that copper ore in small quantities was mined with the magnetite. The country-rock is metamorphosed Devonian slate.

The mine was first worked in 1843. The shaft is in the field in front of the church; it was about 40 ft. in depth, but is now filled in. The mine is flooded, and is said to be a 'wet' mine.

The output was 200 tons in 1873, but in 1874 was merged in that of other mines in the Mineral Statistics.

11. COLDVREATH

Roche

(Standing)

Shafts, openworks and adit, situated near Coldvreath Farm, a mile south of Roche.

One-inch New Series Ordnance and Geological Map 347; Six-inch Cornwall 41 S.E. Main Shaft: Lat. $50^{\circ} 23' 10''$. Long. $4^{\circ} 49' 59''$.

Coldvreath Mine was once called Killivreath.

There are two lodes, nearly parallel the one with the other, of which the western or main lode crops out for a distance of about

¹ 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 158.

² 'The Hensbarrow Granite District,' 8vo, 1878, p. 46.

1,000 yds. It courses roughly north-and-south, is nearly vertical or underlies steeply west, and is about 9 ft. wide. The second lode in places almost joins the main lode and crops out for a distance of about 800 yds.; it is about 3 ft. wide. The country-rock is metamorphosed Devonian slate and andalusite mica-schist.

The ore is hard limonite or brown hæmatite, which occupies a fissure about 10 ft. wide in the mica-schist. The following analysis¹ shows the average composition:—

Peroxide of iron	...	...	...	...	...	...	76.0
Silica	...	...	...	...	...	...	5.6
Alumina	...	...	...	...	...	...	4.6
CaO, MgO, MnO	...	...	...	...	...	...	traces
P ₂ O ₅...	...	...	...	...	...	...	traces
Moisture and combined water	...	...	...	...	...	...	13.0
							99.2
							53.2
Metallic iron	...	...	...	...	...	...

The mine was formerly worked by opencast pits; the principal one, situated on the south-south-western edge of Coldvreath, is 40 ft. deep and 100 yards long. The lode was proved in an engine-shaft to a depth of 17 fathoms; there is also an adit 9 fathoms long.

The output amounted to 14,570 tons during the years 1854 to 1864, 1870 to 1875, and 1882. In the last year mentioned 550 tons were sold, containing 49.14 per cent. of iron. The outputs for 1856 and 1881 are merged in those of other mines.

12. PAWTON MINE

St. Breock

(*Standing*)

Shafts nearly half a mile west of Pawton, 2½ miles south-west of Wadebridge.

One-inch New Series Ordnance and Geological Map, 336; Six-inch Cornwall 25 S.W. Engine-shaft: Lat. 50° 29' 36". Long. 4° 53' 15".

The lode² varies in width from 1 ft. to 30 ft., but averages 6 to 8 ft. It underlies east at 10° and bears N. 18° W. The country-rock is Devonian slate.

The greater part of the ore is brown hæmatite, sometimes with botryoidal structure. There is, however, much red hæmatite down to the 22-fathom level, but below that depth spathic iron-ore is mixed with it. For analyses, see pp. 60, 61.

The principal shaft (the engine-shaft) was sunk to a depth of 115 fathoms, of which over 90 fathoms are below adit-level. There are six other shafts, two N.N.W. and four S.S.E. of the engine-shaft, and ten levels driven parallel to the lode. At the south-west end of the sett adit-level is 25 fathoms beneath the surface. The lode is not entirely worked out.

¹ 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 141.

² J. H. Collins, 'On the Pawton Iron Mine,' *Rep. Min. Assoc. Corn. and Devon* for 1875, p. 26 (1876); 'The West of England Mining Region,' p. 275. See also 'Geology of Padstow and Camelford' (*Mem. Geol. Surv.*), 1910, p. 101.

From 1861 to 1864 the output was 49,350 tons of brown hæmatite; in 1873 and 1874, 5,372 tons. There was an output in 1865 also, but in the Mineral Statistics this is included with Tremoor.

13. LANJEW AND BLACKHAY MINES

Withiel, Bodmin

(*Abandoned*)

Levels and shafts half a mile west of Withiel, 5 miles west-by-south of Bodmin. Stations: Roche (G.W.R.), 4 miles southward by road; Bodmin (G.W.R.), 7 miles by road.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 33 N.E. and S.E. Lanjew: Lat. $50^{\circ} 27' 7''$. Long. $4^{\circ} 50' 10''$. Blackhay: Lat. $50^{\circ} 27' 24''$. Long. $4^{\circ} 50' 10''$.

Known also as Lanjeth or Langeth and as Nanjeth.¹

The lode courses north-and-south and underlies west at 1 in 6. It is about 8 to 10 ft. wide and consists of red hæmatite and limonite. The ore is said to be of as good quality as any in Cornwall. The country-rock is Devonian slate and calc-flinta.

The lode was worked by two mines: Blackhay, at the northern end, and Lanjew, at the southern end of the outcrop. There is a shaft 10 fathoms deep meeting a trial-level. Adit-level is 25-30 fathoms below the trial.

In 1857 to 1859, 2,390 tons of ore were sold; some sold in 1874 is merged, in the Mineral Statistics, in the outputs from other mines. From the Blackhay Mine 4,330 tons were sold in 1872-4 and 1879-80.

14. COLBIGGAN (ROCHE) AND ROSEWARRICK (LANIVET) MINES

15. RETIRE AND WHEAL JAMES (WITHIEL) MINES,
near Bodmin

(*Disused*)

These four mines, all within a mile of each other, in the order given above, are situated in succession from south to north on the Colbiggan Lode.

Colbiggan: Shafts 250 to 450 yds. N. of Lower Colbiggan. $1\frac{1}{2}$ miles S.E. of Withiel. Main Shaft: Lat. $50^{\circ} 26' 22''$. Long. $4^{\circ} 48' 26''$.

Rosewarrick: Shafts 750 yds. W. by N. of Rosewarrick. Main Shaft: Lat. $50^{\circ} 26' 28''$. Long. $4^{\circ} 48' 25''$.

Retire: Shaft 300 yds. N.E. of Retire, three-quarters of a mile S.E. of Withiel. Lat. $50^{\circ} 26' 50''$. Long. $4^{\circ} 48' 32''$.

Wheal James: Shaft 500 yds. N.N.E. of Retire. Lat. $50^{\circ} 26' 57''$. Long. $4^{\circ} 48' 33''$.

¹ A 'Nanjeth' Mine at St. Stephen's by St. Austell is mentioned on p. 148 of the Geol. Survey Memoir on 'Bodmin and St. Austell,' and an analysis of its limonite given; but no further details are known.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 33 S.E. and N.E.

The lode, which has been traced for over a mile from south to north, traverses slightly calcareous soft Devonian slate, which in places has been converted into an intensely hard calc-hornfels containing garnet and axinite. It courses N. 10° W., is nearly vertical, and is said to vary in width from 5 to 14 ft., occasionally to 18 ft.

The ore is red and brown hæmatite and limonite, mixed with black oxide of manganese.

At the Colbiggan Mine a shaft was sunk to a depth of 25 fathoms, which proved the lode to be from 6 to 8 ft. thick, while two other shafts are 7 and 15 fathoms deep respectively. According to local information, the mine suspended work in less than two years, more on account of fall in price of ore than through exhaustion of the ore.

At the Rosewarrick Mine there are three shafts each about 7 fathoms deep, at which depth the lode varies from 6 to 18 fathoms in width.

At the Retire Mine the depth of the shaft is unknown.

At Wheal James the engine-shaft is 20 fathoms deep. Farther north, in Corn. 33 N.E., an adit, driven in a W.S.W. direction from the brook-side east of Withielgoose, cut the lode at 420 yards.

From Colbiggan, 4,930 tons were raised in 1874. From Retire, 23,960 in 1856-70; this mine is said to have been worked out down to adit-level.

16. WEST DOWNS OR WOODLEY IRON MINE

Lanivet

(*Abandoned*)

Shafts situated three-quarters of a mile W.S.W. of Lanivet, 3 miles S.W. of Bodmin. Stations: St. Lawrence Halt or Bodmin.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 33 S.E. Lat. $50^{\circ} 26' 20''$. Long. $4^{\circ} 46' 43''$.

On the six-inch map (ed. 2, 1908) it is named Westdowns Mine. It has been called also Woodley and Lanivet.

The lode occupies a fissure about 9 ft. wide, in purple and green gritty Devonian slate, with tourmalinised bands, and intersects a stanniferous elvan.

The ore consists of red and brown hæmatite and spathose iron-ore and manganese; it is remarkably free from sulphur and phosphorus.

A shaft was sunk a few fathoms and a level driven from it to cut the lode. Other lodes in the sett have been found by means of prospecting pits.

The mine was worked in 1859 and from 1871 to 1878 as Lanivet and West Downs, during which periods its output of hæmatite and spathose iron-ores was 13,560 tons. Woodley produced 71 tons of hæmatite in 1861.

17. NANSTALLON OR NEWDOWNS MINE

Bodmin

(Abandoned)

Openworks and shafts a mile west of Nanstallon, west of Bodmin. Station: Nanstallon Halt (L. and S.W.R., Bodmin and Wadebridge Line), or Bodmin (G.W.R.), $3\frac{1}{2}$ miles.

One-inch New Series Ordnance and Geological Maps, 347 and 336. Six-inch Cornwall 33 N.E. and 25 S.E. South shaft: Lat. $50^{\circ} 28' 3''$. Long. $4^{\circ} 47' 17''$.

The mine is named Newdowns Mine on the six-inch map (ed. 2, 1908), but appears to be identical with the Nanstallon Mine commonly referred to as in the Parish of Lanivet. It lies half a mile N.E. of Ruthernbridge.

A series of north-and-south lodes. The principal one, consisting of three more or less parallel branches, has been traced for $1\frac{1}{3}$ miles. Two of the lodes average 6 ft. and one 3 ft. in thickness. Half a mile farther south, on Mulberry Downs, a lode of iron-ore in the same course crops out for 550 yards, and is shown on the six-inch geological map. Its southern end is 100 yards east of the openwork of the Mulberry Tin Mine. The country-rock is Devonian grit.

The ore is brown hæmatite, in places somewhat sparry, but for the most part it consists of fibrous kidney ore. It contains 74.64 per cent. of peroxide of iron, 12.3 of silica and alumina, 0.68 of phosphoric acid, and about 11 of water.¹

In 1859 and 1860 a total of 2,124 tons of hæmatite was raised.

18. BOSCARNE MINE

Bodmin

(Abandoned)

A level situated 300 yds. W.S.W. of Boscarne, 4 miles south-east of Wadebridge. It is on the northern bank of the river Camel, 300 yards west of Boscarne Mill and opposite Nanstallon Church (2 miles west of Bodmin).

One-inch New Series Ordnance and Geological Map, 336; Six-inch Cornwall 34 N.W. Lat. $50^{\circ} 28' 24''$. Long $4^{\circ} 46' 0''$.

The lode runs north-and-south for a distance of 1,500 yards, and averages about 6 ft. in width. The country-rock is Devonian grit.

The ore is mainly brown hæmatite. It consists² of 72.25 per cent. of peroxide of iron, 12 of silica and alumina, 0.46 of phosphoric acid, and 11.2 of water.

An adit was driven in a north-eastward direction for a distance of 300 yds., to a depth of 40 yds.

There is no record of output later than 1861, when 65 tons of hæmatite were obtained.

¹ J. T. Woodhouse, *Journ. Iron and Steel Inst.*, vol. ii, 1871, p. 29.

² *Ibid.*, p. 28.

19. RUBY, KNIGHTOR, AND TREVERBYN IRON MINES

St. Austell

(Abandoned)

These three mines, all within half a mile of each other, are situated on the Ruby iron-lode. In the order given above they follow in succession from south to north.

The mines fall within the one-inch New Series Ordnance and Geological Map, 347; and Six-inch Cornwall 42 S.W.

Ruby: Shafts, 350 yds. N.W. of Trethurgy, $2\frac{1}{2}$ miles N.E. of St. Austell. Lat. $50^{\circ} 22' 5''$. Long. $4^{\circ} 45' 50''$.

Knightor: Shaft, 250 yds. N.N.W. of Knightor. Lat. $50^{\circ} 22' 22''$. Long. $4^{\circ} 45' 56''$.

Treverbyn: Shaft, 220 yds. S.S.E. of Treverbyn. Lat. $50^{\circ} 22' 27''$. Long. $4^{\circ} 45' 58''$.

The lode is said by Collins¹ to be traceable from the south coast near Crinnis Island ($2\frac{1}{2}$ miles east of St. Austell) northward to the parish of Withiel, a distance of nine miles; but it is discontinuous, and in the killas carries only a little chalybite and blende. On entering the granite near Trethurgy, and thence to the Knightor Mine, it contains pure hæmatite. Between Treverbyn and Colbiggan the fissure carries very little ore, but is again richer near Withiel (p. 71). Its course is thus N. 20° W. The lode is nearly vertical and of variable width, from a few inches up to 12 ft., and narrowing considerably at depth. In places there are two lodes, which, when worked together, were profitable.

The ore was red hæmatite of remarkable purity, some picked samples containing 96.2 per cent. of iron peroxide, and neither sulphur nor phosphorus. The average iron-percentage of the ore raised was 60. Some soft ore from a flucan supplied excellent material for paint-making.

At the Ruby² Mine the workings extend to a depth of 40 fathoms, and were reached by shafts and an adit-level. There was also an opencast pit 20 or 30 ft. deep on the back of the lode. At Knightor the workings were shallower.

The Ruby Mine produced 2,000 tons in 1862; Ruby and Knightor, 44,700 tons in 1864-71; Ruby and Trethurgy, 25,150 tons in 1872-80; Treverbyn, 204 tons in 1865; Knightor and Treverbyn, 4,580 tons in 1872-74. The owner states that the total output was about a million tons. The Ruby Mine was working in 1847 and closed in 1876.

Nearly all the ore above adit-level has been extracted, there is heavy water, and the country is hard granite. The prospect of the lode being reopened, therefore, is regarded as remote.

¹ 'On the Hensbarrow Granite District,' 8vo, 1878, p. 44; 'Observations on the West of England Mining Region,' 8vo, 1912, pp. 244-5.

² 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 155.

20. TREFFRY AND PRIDEAUX MINES

Luxulian, Lostwithiel

(Abandoned)

Treffry: Shafts situated in a wood called The Preserves, about 800 yards S.S.W. of Prideaux House, $1\frac{1}{4}$ miles S.E. of Luxulian. Lat. $50^{\circ} 21' 55''$. Long. $4^{\circ} 44' 5''$.

Prideaux: Shafts in Prideaux Wood, near Tywardraeth Highway. The lode is exposed in a china-clay pit (Lat. $50^{\circ} 22' 3''$. Long. $4^{\circ} 42' 55''$) belonging to the Prideaux Wood China Clay Works.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 42 S.W.

The country-rock is granite at Treffry, granite and Devonian slates, metamorphosed, at Prideaux.

According to Collins,¹ "Prospecting work has been carried on at Restinnis, Treskilling, Levrean, Canna, and Savath; also at the *Treffry Iron Mine*, in the Luxulyan valley, where, for a length of 60 fathoms, the lode was worked away for a height of 14 fathoms, and yielded between 9,000 and 10,000 tons of ore, most of it being red hematite of excellent quality." The Treffry lode runs N. 18° W. and dips east at 85° .

According to the Home Office Returns, Treffry Consols and Treffry and Restineas had an output for the years 1862 and 1873 to 1877 of 6,455 tons of red hematite. Prideaux produced 2,200 tons in 1862 and 1864.

The Prideaux Mine has recently been reopened.

21. RESTORMEL IRON MINE

Lanlivery, Lostwithiel

(Standing)

Openworks, shafts, and adit, half a mile N.W. of Lostwithiel Station, and the like distance S.S.W. of Restormel.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 42 N.E. Old Openwork: Lat. $50^{\circ} 24' 53''$. Long. $4^{\circ} 40' 35''$.

The Restormel lode² consists of two more or less parallel veins a few fathoms apart, occupies a cross-course in Devonian slate, bears about N. 15° W., and fades to the east at 5° to 20° . The compound lode is in places 2 to 4 fathoms wide where the component veins join, or where the country-rock between them becomes impregnated with iron-ore.

Collins³ states that the lode is traceable northward from Restormel through Lanhydrock to Balsealt, a distance of at least 5 miles. In the Great Wood at Lanhydrock it is indicated by an outcrop of quartz and iron-ore 60 yds. long, with a bearing of

¹ 'The West of England Mining Region,' pp. 245, 370.

² Henwood, W. J., 'On the Metalliferous Deposits of Cornwall and Devon,' *Trans. Roy. Geol. Soc. Corn.*, vol. v. 1843, p. 128. 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 154. J. H. Collins, 'On the Hensbarrow Granite District,' 8vo, Truro, 1878; 'Observations on the West of England Mining Region,' 8vo, Plymouth, 1912, pp. 246-7.

³ *Observations, &c.*, p. 246.

N. 10° W.¹ Southward the fault-fissures appear to have been traced through Castle and Castle Dore to the coast at Little Gribbin.

The ore throughout was carried in a quartzose veinstone, in which occurred numerous cavities or vugs, lined with beautiful mineral specimens, for which the mine has long been famous. Massive hæmatite was the principal ore obtained. Associated with it were the hydrated oxides göthite and limonite, which occurred in alternating bands. Göthite, usually rather a rare mineral, was found commonly at Restormel, some examples being of exceptional beauty. It is composed of peroxide of iron with about 10 per cent. of water, and may be regarded as ferric hydrate. Acicular crystals of göthite forming fibrous aggregates, and locally called 'needle iron,' were a characteristic feature of the lode.

It is possible that the Restormel lode is a gozzan or 'iron hat' to a lead or copper lode, as has been suggested in the case of the Great Perran Lode (p. 62).

Some ore was got in opencast pits, 40 ft. deep, and extending along the crop for nearly three-quarters of a mile. But the greater part was mined, and the workings were drained by an adit, 240 fathoms long, opening to the Fowey Valley on the east. According to Collins, in 1858 the workings had reached a depth of 50 or 60 fathoms from the surface. Large sections of ore have been stoped away for a length of nearly three-quarters of a mile and to a depth of 60 fathoms below adit-level. An old shaft, 300 ft. deep, is still in good condition. The mine was re-timbered about four years ago from the adit-entrance to the shaft, but a large fall of roof has since blocked up part of the levels. In July, 1917, the mine was flooded to adit-level.

The first recorded output is for the year 1855, when 20,807 tons of hæmatite were raised; between 1855 and 1869, 90,810 tons are recorded. From 1870 to 1883 the mine yielded 30,986 tons. Between 1855 and 1883 the price of the ore averaged 8s. per ton. In 1882 the ore contained 44 per cent. of iron. In 1910 the output was 688 tons of 42 per cent. ore.

A longitudinal section of the mine, showing the extensive stoping, is given in the Geological Survey Memoir already quoted. Much of the ore has been removed down to a depth of 60 fathoms below adit-level, and it is thought probable that the mine is exhausted down to the first level below adit. About 1910 some work was going on at the mine.

22. BODINNICK MINE

St. Stephen-in-Brannel

(Abandoned)

Openworks and shafts 500 yds. S.W. of Bodinnick, three-quarters of a mile S.S.E. of St. Stephen-in-Brannel. Station: Grampound Road (G.W.R.), 3 miles S.W. by road.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 50 S.W. Lat. 50° 19' 50". Long. 4° 53' 12".

¹ 'The Geology of the Country around Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 154.

There are two lodes in Devonian slate, one bearing E. 38° S., the other E. 68° S. The former cuts and heaves the latter, and the mine is situated at the point of intersection. The ore is said by Woodhouse¹ to be 'compact brown hæmatite,' and by Collins² to be siliceous brown hæmatite. Magnetite and brown iron-ore were obtained.³

From 1858 to 1863, 3,250 tons of iron-ore were sold.

23. SOUTH TERRAS MINE

St. Stephen-in-Brannel, Grampound Road

(Abandoned)

Shafts and adit at Tolgarrick, a mile S.W. of St. Stephen-in-Brannel, and 5 miles west of St. Austell. Station: Grampound Road (G.W.R.), 2 miles south-west.

One-inch New Series Ordnance and Geological Map, 347; Six-inch Cornwall 50 S.W. Lat. $50^{\circ} 20' 0''$. Long. $4^{\circ} 54' 15''$.

This mine, the noted Uranium or Union Mine, is situated in the Fal Valley, three-quarters of a mile south of Terras Bridge.

The country-rock is killas and intrusive greenstone, and the sett is traversed by three elvans and by two lodes, the Uranium Lode and the Great Lode. The Great Lode has been worked at the surface for magnetic iron-ore and umber; but at depth, about the 50-fathom level, these ores give place to zinc-blende, mispickel, copper-pyrites, tinstone and silver. The lode has a bearing of E. 20° S., and occurs in a greenstone.⁴

The composition of the magnetite is shown by the following analyses:—

	I.	II.	III.
Magnetic oxide of iron	84.24	—	—
Peroxide of iron	3.84	69.36	62.81
Protoxide of iron	—	18.36	31.28
Protoxide of manganese	1.06	0.18	—
Oxide of manganese	—	—	0.46
Silica	7.51	7.44	1.84
Alumina	1.35	0.86	0.69
Lime	trace	2.10	0.37
Magnesia	trace	0.14	trace
Phosphoric acid	trace	0.03	0.05
Sulphuric acid	trace	trace	—
Sulphur	—	—	0.04
Carbonic acid	—	—	2.30
Combined water	—	—	0.53
Water	2.00	1.53	trace
	<hr/> 100.00	<hr/> 100.00	<hr/> 100.37
Metallic iron... ..	63.67	62.83	

I and II. From J. D. Kendall, 'The Iron Ores of Great Britain and Ireland,' 8vo, 1893, p. 125.

III. Anal. by E. Riley, quoted in 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 157.

¹ *Journ. Iron and Steel Inst.*, vol. ii, 1871, p. 28.

² 'The West of England Mining Region,' p. 241.

³ 'Geology of Bodmin and St. Austell' (*Mem. Geol. Surv.*), 1909, p. 137.

⁴ *Ibid.*, p. 157.

Between 1873 and 1881 the output was 4,923 tons of brown hæmatite, 762 tons of ochre and umber, and 500 tons of magnetite.

TRURO AND HELSTON DISTRICT

The mines in this district of Western Cornwall are few and scattered; the following are the most important:—

24. WHEAL FALMOUTH AND WHEAL SPERRIES

Kea, near Truro

(Abandoned)

Shafts between Hugu and Baldhu, about 3 miles W.S.W. of Truro.

One-inch New Series Ordnance and Geological Map, 352.

Wheal Falmouth: Six-inch Cornwall 57 S.W. Approximate

Lat. 50° 15' 0". Long. 5° 7' 0".

Wheal Sperries: Six-inch Cornwall 64 N.W. Approximate

Lat. 50° 14' 50". Long. 5° 7' 45".

A number of lodes, ranging about north-east and south-west, have yielded a great variety of ores, including those of tin, copper, lead, silver, zinc, arsenic, and iron, with ochre, umber, and iron-pyrites. The country-rock is slate of Lower Palæozoic age.

The Wheal Falmouth lode (presumably the South Wheal Falmouth) strikes E. 40° N. and underlies south-east at 20° to 46°. From the 30 to the 70 fathom level the lode consists of chlorite, decomposed slate, and earthy brown iron-ores, copper and iron-pyrites; and, at the 50 fathom level, phosphate of iron; also blende, purple copper-ore, galena, etc.¹

The lodes were worked by numerous shafts close to their outcrops. The mines were known as Wheal Falmouth, East Wheal Falmouth (in the adjacent parish of Kenwyn), Wheal Jane, West Wheal Jane, Wheal Sperries, etc.

Collins² remarks that Wheal Falmouth is a very ancient mine, and that it was worked in connection with Wheal Sperries as 'Falmouth and Sperries'; that a company was registered in 1907 as the Falmouth Consolidated Mines, Limited, to work properties in and near the parish of Kea, including Wheal Jane and others, and that extensive surface-works were erected at Wheal Jane and in the Carnon Valley, and powerful electrical and other machinery installed. In 1864 Wheal Falmouth was 104 fathoms below adit; Wheal Jane in 1870 was 180 fathoms deep.

The outputs of some of these mines between 1848 and 1905 are as follow:—

	Gozzan and Iron Oxide.	Iron-pyrites and Sulphur Ores.	Ochre and Umber.
	tons.	tons.	tons.
Wheal Falmouth and Sperries ...	10,474	47,800	—
Wheal Jane	3,666	33,340	100
North Wheal Jane	340	370	—
West Wheal Jane	207	27,170	—

¹ 'Geology of Falmouth and Truro and of the Mining District of Camborne and Redruth' (*Mem. Geol. Surv.*), 1906, p. 228.

² 'The West of England Mining Region,' 8vo, Plymouth, 1912, p. 478.

25. CONSTANTINE OR BROGDEN'S IRON MINE

Constantine, near Penryn

(Abandoned)

Shafts, a mile S.E. of Constantine, 5 miles E. by N. of Helston. Station: Helston (G.W.R.).

One-inch New Series Ordnance and Geological Map, 359; Six-inch Cornwall 77 N.W. Lat. $50^{\circ} 6' 34''$. Long. $5^{\circ} 9' 4''$.

The mine was leased by Messrs. Brogden and Sons in 1868, and was working in 1871.

According to G. Noble,¹ the lode has a bearing of E. 5° S., and an underlie of about 17° to the south, the width varying from 6 in. to 6 ft. Another lode on the south, which at its nearest point to the former is about 4 ft. distant, has a bearing of E. 25° S., and a width of from $1\frac{1}{2}$ to 6 ft. The country-rock is Lower Palæozoic slate.

The bearings as given by Noble do not tally with the Six-inch Geological Map, which shows the lode worked at the mine to run E. 22° N., while the other lode, to the south of the mine, runs E. 15° S., and crosses the first at a point about half a mile W.S.W. of the mine. Noble's bearings may be magnetic and not true bearings.

The ore is brown hæmatite, said to contain 52 per cent. of iron. It is somewhat quartzose and is traversed by fissures containing clay.

The output was 2,000 tons in 1873.

SMALLER MINES

Of the many smaller workings for iron-ore little information is available. The following table has been compiled mainly from the Geological Survey Memoirs² and from Collins's 'Observations on the West of England Mining Region'³ :—

ONE-INCH NEW SERIES MAP, 347 (BODMIN)

Mine.	Parish.	Six-inch Map (Cornwall).	Output in tons (mainly hæmatite.)	Period.
Alma ...	?	?	50	1872
Bigbees ...	Lanivet ...	?	60	1906
Haden or Burney House	Roche ...	41 N.E.	400	1873
Iron Mine ...	St. Austell ...	? 50 N.E.	7211	1855-66
St. Stephen ...	St. Stephen-in- Brannel...	? 50 N.W.	400	1873-4

¹ 'Remarks on Mineral Veins in the Parish of Constantine,' 39th Ann. Rep. Roy. Corn. Poly. Soc. for 1871, p. 74 (1872), and Rep. Miners' Assoc. Corn. and Devon, 1872, p. 45.

² 'Geology of Bodmin and St. Austell' (Sheet 347); 'Geology of Falmouth and Truro and of the Mining District of Camborne and Redruth' (Sheet 352); 'Geology of the Land's End District' (Sheets 351 and 358); 'Geology of Padstow and Camelford' (Sheets 335 and 336).

³ 8vo, Plymouth, 1912.

ONE-INCH NEW SERIES MAP, 347 (BODMIN)—*continued.*

<i>Mine.</i>	<i>Parish.</i>	<i>Six-inch Map (Cornwall).</i>	<i>Output in tons (mainly hæmatite).</i>	<i>Period.</i>
Tregawne ...	Withiel ...	33 N.E.	130 (some spathic also)	1859
Tregonetha ...	St. Wenn ...	33 S.W.	1543	1873-6
Tregullan and Tretail ...	Lanivet ...	34 S.W.	10,040	1856-60, 1873-4
Tresibble ...	? Luxulian ...	? 41 N.E.	1,833	1859
Trewhela and Benallack ..	St. Enoder ...	40 S.E.	626	1859-61

ONE-INCH NEW SERIES MAP, 352 (FALMOUTH)

Treluswell ...	St. Gluvias ...	71 N.W.	Some magnetite	—
Great Wheal Busy ...	Kenwyn ...	57 S. W.	38	1848-1905
Nangiles and Wheal Andrew	Kea and Gwennap.	64 N.W.	16	1845-1905
St. Day United	Gwennap ...	64 N.W.	38	1848-1905

ONE-INCH NEW SERIES MAP, 335 (TREVOSE HEAD)

Carnewas ...	St. Eval ...	32 N.W.	940	1871, 1874
--------------	--------------	---------	-----	------------

ONE-INCH NEW SERIES MAP, 336 (CAMELFORD)

Trefresa ...	St. Minver ...	19 S.W.	Brown hæma- tite.	—
Tregelles ...	St. Kew ...	19 S.E.	—	About 1855
Trelow ...	St. Issey ...	24 S.E.	—	About 1864

ONE-INCH NEW SERIES MAP, 346 (NEWQUAY)

Ladock Mines ..	Ladock ...	49 S.E.	7,600	1860-5, 1872-5
Perran Bay ...	Perranzabuloe	48 N.W.	165	1866
Perran Mines ..	Perranzabuloe	48 N.W.	4,000 (some spathic also)	1857
Rose ...	Perranzabuloe	48 N.W.	135 (some spathic also)	1865, 1876
St. Columb Mines ...	St. Columb Minor	39 N.E., 40 N.W.	386	1858, 1872
Speedwell ...	Cubert ...	? 39 S.W.	7,467	1858

ONE-INCH NEW SERIES MAP, 351 (PENZANCE)

Binner Downs .	Crowan ...	69 S.E.	100	—
Castle ...	St. Just ...	67 S.W.	75	—
Trebarvah or Wheal Castle	Perranuthnoe .	75 N.W.	1,730	1852-74.

INDEX

- Abergele District, 21-25.
 ——— Hæmatite Co., 25.
 Adams Mine, 55.
 Allenheads, 12.
 Aller Mine, 55.
 Alma Mine, 79.
 Alsopmoor Plantation, 26.
 Alston District, 11-14.
 ——— Prospecting Syndicate, Ltd., 13.
 Analyses, iron-ores, Cornwall, 60, 61, 64, 70, 73, 77; Devon, 48, 53; Somerset, 30, 34, 42, 43; Wales, 22; Weardale, 5, 6. *See also* Iron.
 ———, paint-ore, 48.
 Andrew, Wheal, 80.
 Anstie, J., 28, 30.
 Ardale Head, 12, 14.
 ——— Beck, 14.
 Arsenic, 49, 77, 78.
 Ashes House, 10.
 Ashton Hill, 28, 29.
 ——— Vale, 30.
 ——— Furnaces, 30.
 Atlas Tin Mine, 54.
 Attwood, C., 4.

 Baker's Mine, 39.
 Baldhu, 78.
 Ballajora Iron Mine, 27.
 Bampfylde Hill Mines, 44.
 Banwell, 28.
 Barle, River, 41, 42.
 Barnstaple District, 42-44.
 Barras Nose, 58.
 Barrow Farm Mine, 34, 37, 38.
 Barton's Shaft, 67.
 Barytes, 19, 30, 55.
 Beacon Batch, 28.
 Bearland Wood Mine, 35, 38.
 Bell, I. L., 5, 7, 11.
 ——— Bros., Ltd., 11.
 ——— Metal Mining Co., Ltd., 23.
 Bennah Mine, 55.
 Berryman's Shaft, 65.
 Bessemer, H., 59, 62, 66.
 ——— steel, 59, 66.
 Betsey Mine, 38.
 Bigbees Mine, 79.
 Big Iron Pit, 64.
 Binegar, 28.
 Binner Downs Mine, 80.
 Birch Tor Mine, 47, 51, 54.
 Blackhay Mine, 71.
 Blackwell, Mr., 34.
 Blagdon, 28.
 Blue Gate, 43.

 Bodfari Mine, 15, 19.
 Bodinnick Mine, 58, 60, 76.
 Bog House, 11.
 Boringdon Consols, 56.
 Borlase, W., 56.
 Boscarne Mine, 58, 60, 73.
 Botallack, 58.
 Bovey Tracey, 46, 47, 49, 50, 55.
 Bracken Syke Vein, 12.
 Brandon Walls, 11.
 Bratton Fleming Mines, 44.
 Bremley (Brimley) Mine, 44.
 Brendon Hills, 31-40.
 Brimley (Bremley) Mine, 44.
 Bristol District, 28-31.
 Brixham, 46-48, 52.
 Broadfield Down, 28.
 Brockwell, 31.
 Brogden's Mine, 58, 79.
 Brough, 12.
 Bryant, N., 64.
 Bryn-Sion, 19.
 Buckfastleigh, 54.
 Bulkamore Iron Mine, 56.
 Burcomb, 43.
 Burney House Mine, 79.
 Burrow Farm, 37, 38.
 Burtree Pasture Mine, 6.
 Butterley Iron Co., 25.
 Buttons, hæmatite used for, 26.
 Byrne, R., 34, 36.

 Caerwys District, 18, 19.
 Calcination of ore, 44, 59.
 California Mine, 38, 40.
 Camden, W., 56.
 Carew Mine, 34, 37.
 Cargo Fleet Iron Co., Ltd., 14.
 Carnarvon, Old and New Mines, 37.
 Carnewas Mine, 80.
 Carricks Mine, 5-8.
 Carr's Vein, 8.
 Cassiterite, 51, 54, 77, 78.
 Castle of Oomfort, 29.
 Castle Mine, 80.
 Challacombe, lode at, 45.
 Chalybite. *See* Spathic ore.
 Charcoal-iron, 34.
 Chargot Wood, 38.
 Chilcompton, 28.
 Child, Mr., 48.
 Christow, 55.
 Clapton-in-Gordano, 28.
 Cleveland ores, 4.
 Click, Wheal, 69.
 Clifton, 28, 30.
 Cloister Mine, 53.
 Coalpit Heath, 28.
 Cobalt, 15-17.

- 'Cockle' or schorl-rock, 51, 52.
 Colbiggan Mine, 58, 71, 72.
 Cold Knuckles, 8.
 Coldvreath Mine, 58, 60, 69, 70.
 Collins, J. H., 33, 34, 36-40, 42, 44,
 46, 50, 53, 54, 59-62, 64-67, 69,
 70, 74-80.
 Colton Mine, 34-36.
 Colwyn, 25.
 Combe Martin, 44, 45.
 Comberow, 36.
 Compton Martin, 28.
 Constantine Mine, 58, 79.
 Cook, Dr., 30.
 —, R., 49, 52.
 Copper ores, 18, 39, 42, 44, 49, 59,
 62, 63, 66, 69, 77, 78.
 Cornham Ford Mine, 43.
 Cornwall, 46, 56-80.
 Craig Green Vein, 12.
 Craigs Level, 8.
 Crawley Vein, 10.
 Cromhall, 28.
 Cross-courses, 7, 59.
 Cross Fell, 12.
 Crowbarn Iron Mine, 44.
 Cubert, 64, 65.
 Cutcombe Barrow Vein, 39.
 Cwm, 15-18.

 Darwen and Mostyn Iron Co., 19, 22,
 23.
 Dawson's Vein, 8, 10.
 Deerpark (Somerset), 42, 43.
 — Mine (Cornwall), 57, 67.
 De la Beche, H. T., 31, 45, 46, 56.
 De Rance, C. E., 12, 23.
 Devon, North, 31-45.
 —, South, 46-56.
 'Devonshire sand,' 46, 47, 51.
 Dialogite, 33.
 Dick, A., 5.
 Dingle Mine, 21.
 Dinorben, 25.
 Drews Mine, 53.
 Drynane Mine, 27.
 Duchy Peru Mine, 57, 60-63, 66, 67.
 Dulverton District, 42, 44.
 Dyehouse Mine, 69.
 Dyserth and Cwm Mines, 15-18.

 Easton-in-Gordano, 28.
 Ebbw Vale Co., 34-37, 39.
 Edith, Wheal, 58, 68.
 Eisen (Eyeson) Hill, 33, 35, 40, 41.
Eisenpecherz, 41.
 Eliza, Huel, 42.
 Elton Common, 26.
 Elworthy (Yeanon) Mine, 36.
 Etheridge, R., 28.
 Ettersgill, 11.
 Eyeson (Eisen) Hill, 33, 35, 40, 41.

 Exford Iron Ore Co., 41-43.
 Exmoor District, 41-43.
 — Mine, 42, 43.
 Exmouth Mine, 55.

 Falmouth Consolidated Mines, Ltd.,
 78.
 —, Wheal, 58, 78.
 Far Cut, 11.
 — Vein, 8-10.
 Farey, J., 26.
 Faults, Dingle, 21; Vale of Clwyd,
 19, 21; in Bristol Coalfield, 28.
 See also Veins.
 Fell-Top Limestone, 11.
 Ferrubron Manufacturing Co., 52.
 Five Acres Mine, 53.
 'Flats,' 7, 9, 10, 21, 23.
 Florence Mine, 44.
 Florey Hill Mine, 38.
 Fluorspar, 6, 10, 59.
 Foster, C. Le Neve, 16, 46, 49.
 Four Fathom Limestone, 6, 10.
 Foxdale, 26.
 Frampton Cottrell, 28-30.
 Frankmills Mine, 48, 55.
 Frome, 28.
 Fryden Dale, 25, 26.
 Furnaces, 30, 47.
 Furzeham Mine, 53.

 Galloping Bottom, 36.
 Garrigill, 12.
 Gatcham Grange, 26.
 Glebe Mine, 27.
 Gledlom Mine, 18.
 Golden Valley, 28.
 Goosemoor Mine, 34, 39, 40.
 Göthite, 33, 37, 43, 58, 76.
 Gozzan (Gossan), 62, 63, 76, 78.
 Gravel Hill Mine, 57, 63, 64.
 Gravity, specific, of ore, 34.
 Great Limestone, 6-11, 13, 14.
 — Perran Lode, 58, 59, 61-67.
 — Retallack Mine, 57, 65.
 — Rock Mine, 47, 52.
 — Wheal Busy Mine, 80.
 Groove Heads Vein, 8, 10.
 Gupworthy Mines, 33, 34, 38-40.
 Gurney Slade, 28.

 Haden Mine, 79.
 Hæmatite, brown, Alston, 1-3, 11,
 12, 14; Cornwall, 1-3,
 58-60, 62-73, 76-80;
 Devon (North), 1-3, 44,
 45; Devon (South), 1-3,
 46-50, 52-56; Somerset,
 1-3, 28, 31, 33, 37, 39,
 41-43; Wales (North),
 25; Weardale, 1-5, 9,
 11.

- Hæmatite, red, Alston, 1; Bristol District, 1-3, 28-30; Cornwall, 1-3, 58, 60, 62, 63, 65, 68-70, 72-76, 79, 80; Derbyshire, 1-3, 25, 26; Devon (North), 1-3, 31, 44; Devon (South), 1-3, 46-48, 53; Isle of Man, 1-3, 26, 27; Somerset, 1-3, 31, 33, 34, 37-40, 42, 43; Wales (North), 1-3, 15, 16, 18, 19, 21, 22, 24, 25; Weardale, 1.
- micaceous, specular, or shining, Cornwall, 3, 58; Devon (South), 3, 46, 47, 49-52, 54, 55; Somerset, 42; Wales (North), 22.
- origin of, 1, 2, 15, 16, 21, 26, 27, 29, 47, 52.
- Halsgrove Mine, 41, 42.
- Halworthy (Yeanon) Mine, 36.
- Hanging Wells, 11.
- Hangley Cleave Mines, 43.
- Hangman Hill, 45.
- Hand Dale, 25.
- Harptree, 28, 30.
- Hartington, 25, 26.
- Hatherley Mine, 54.
- Hathorne's Shaft, 66.
- Hawkmoor Mine, 55.
- Haytor Mine, 46, 48-50.
- Heasley, 44.
- Heath Hill, 30.
- Hedworth Barium Co., Ltd., 13.
- Heights, 11.
- Helston District, 78.
- Henfryn Mine, 18.
- Hennock, 46, 47, 52, 55.
- Henwood, W. J., 75.
- Higher Blackland Mine, 41, 42.
- Pits, 28, 30.
- Hoar Oak Mines, 43.
- Hoecombe (Holecombe) Levels, 40, 41.
- Holstone Farm, 45.
- Honeymead Mine, 42.
- Honeywell, 40.
- Hope Level, 10.
- Horse Edge, 12; Vein, 12, 13.
- Hugu, 78.
- Ilfracombe District, 44, 45.
- Ilmenite sands, 58.
- Islington, 46, 49, 50, 54.
- Indian Queen Mine, 58, 67.
- Mining and Colour Co., Ltd., 67.
- Ireshopeburn, 8.
- Iron, metallic, percentage in ores, Alston, 12, 14; Cornwall, 64-66, 70, 73, 74, 76, 79; Devon (North), 44; Devon (South), 47, 49, 50, 52-55; Somerset, 30, 35, 43; Wales (North), 16, 20, 22, 23, 25; Weardale, 4-7. *See also* Analyses; Ore.
- , charcoal, 34.
- glance, 58.
- 'hat,' 62, 76.
- oxides, 30.
- phosphate, 78.
- pyrites, 49, 51, 59, 62, 67, 78.
- smelting, 29-31, 34, 36, 44, 47.
- Acton, 28-30.
- Ison Iron Mine, 41.
- Lane 40.
- Jaeger Bros., 21, 23.
- James, Wheal, 58, 71, 72.
- Jane, Wheal, 78.
- Kelly Mine, 47, 50-52.
- Kendall, J. D., 6, 7, 11, 77.
- Kennisham Hill Mine, 34, 38-40.
- Keuper Marl, 29.
- Kilhope Fell, 11.
- Killas, 3.
- Killivreath Mine, 69.
- Kingston, J. T., 49.
- 'Kippel' or schorl-rock, 51, 52.
- Knightor Mine, 58, 60, 74.
- Ladock Mines, 80.
- Lamb Bottom, 28.
- Landore, 30.
- Lanescombe (Lancecombe) Mine, 31, 40.
- Langeth (Lanjeth) Mine, 71.
- Langham Hill Mine, 38, 39.
- Langworthy, 14.
- Lanhydrock, 75.
- Lanivet, 71, 72.
- Lanjew Mine, 58, 71.
- Lanlivery, 75.
- Larcombe Brook, 40.
- Lark Pasture Plantation, 26.
- Laurence Cross Mine, 37.
- Lead ore, 2, 4, 6, 9, 12, 13, 55, 59, 62-67, 78.
- Leather Barrow Vein, 38.
- Level Gate, 11.
- Ligger Bay, 63.
- Point, 61, 63.
- Limonite. *See* Hæmatite (brown).

- Little Limestone, 6, 11.
 Little Woolcombe Mine, 42, 43.
 Llwyni Iron Mine, 19.
 Loathbrook Mine, 38.
 Lodes. *See* Veins.
 Long Ashton, 28.
 Longrigg Mine, 12.
 Lostwithiel, 58, 75.
 Lowe's Vein, 7-9.
 Lubricant, 47.
 Luccombe (Luckham), 31.
 Lustleigh, 46, 47, 50, 55.
 Luxborough, 38.
 Luxulian, 75.
 Lysons, S., 45.

 MacAlister, D. A., 46.
 Madison's Vein, 8, 10.
 Magmatic segregation, 1, 59.
 Magnetic Iron Mine, 69.
 Magnetic sand, 58.
 Magnetic ore or Magnetite, 1, 46,
 48-50, 54, 58, 59, 62, 69, 77.
 Main Joint, The, 16.
 Manaccan, 58.
 Manganese, 14, 17, 18, 21-23, 33, 41,
 50, 68, 72.
 Manganite, 33, 41.
 Manor House Vein, 7, 12.
 Marcasite, 51, 52, 62, 66.
 Margher-e-breck, 27.
 Marian Ffrith, 17.
 Martin, J. S., 47.
 Maryport, 36.
 Maughold Head Mines, 26, 27.
 Meade, R., 4, 11, 44, 47, 48, 53, 54.
 Meesham, 26.
 Melmerby Scar Limestone, 12.
 Mendip Hills Mines, 29.
 Micaceous ore. *See* Hæmatite,
 micaceous.
 Middle Fell, 12.
 Middleton, 11, 12.
 Minehead District, 31.
 Minerals of pneumatolytic origin,
 47, 49-51, 59, 72.
 Mining, Ancient, 36-41; Roman,
 16, 30, 34; Mediæval, 34, 40.
 Moel Hiraddug Mine, 16, 17.
 Mole, River, 44.
 Molland Mine, 44.
 Monmouthshire, 31.
 Morgans, M., 33-41.
 Mount and Trebysken Mine, 57, 64,
 65.
 Mulberry Mine, 60, 73.

 Nangiles Mine, 80.
 Nanjeth Mine, 71.
 Nanstallon Mine, 58, 73.
 Nant-uchaf Mine, 23.
 Narrow Dale, 26.
 Nenthead, 11, 12.

 Newdowns Mine, 73.
 Newhaven, 25, 26.
 Newland, 42.
 Newquay District, 61-67.
 Newton Abbot, 49.
 Nickel, 15, 16, 17.
 Noad, Dr., 48, 60, 61.
 Noble, G., 79.
 North Heasley, 44.
 North Molton District, 44.
 Nunney, 28, 30.

 Ochre, 30, 50, 67, 68, 78.
 Odling, Dr., 48.
 Office Levels, 41.
 Ore, iron, bedded, 45; black, 33;
 blue, 22; botryoidal, 43;
 brown, 33; hard, 36;
 kidney, 47, 65, 73; looking-
 glass, 58; needle, 58, 76;
 nodular, 45; phosphoric,
 13; pitchy, 41; potty, 33,
 37, 39, 41; puddle, 22;
 rider, 4, 6, 7; rocky, 33;
 sandy, 34; shining, 51,
 55; soft, 36; specular, *see*
 Hæmatite; steel, 22;
 white, *see* Spathic; wood,
 58. *See also* Magne-
 tite and Hæmatite,
 micaceous.
 ———— calcination of, 44, 59.
 ———— reserves of, 1, 2, 16, 35, 46,
 47, 59, 62, 65, 67.
 ———— smelting of, 29-31, 34, 36,
 44, 47.
 ———— specific gravity of, 34.
 Ousby, 12, 14.
 Output, tables of; general, 3; Alston
 Moor, 12; Brendon and Eisen
 Hills, 35; Bristol District, 29;
 Cornwall, 78-80; Cwm, 18; Devon
 (South), 54-56; Nant-uchaf, 25;
 Teesdale, 11; Ty'n-y-caeau, 23;
 Weardale, 7, 8.
 Over Haddon, 26.

 Paint-ore, 1, 29, 30, 47, 54, 68, 74;
 analysis of, 48.
 Pant-gwyn, 19.
 Park Fell, 13.
 ——— Grove Sun Vein, 14.
 ——— Vein, 14.
 ——— Vein, 12.
 Parkin Mine, 53.
 Pattinson, J., 60.
 Pawton Mine, 58, 60, 61, 70.
 Pelsall, 30.
 Pennycombe Water, 41.
 Penryn, 58, 79.
 Pen-y-coed, 21.
 Percentage of iron in ores, *see* Iron.
 Percy, J., 5, 34.

- Perran Bay Mine, 80.
 ——— Lode, The Great, 56, 58, 59,
 61, 62, 65, 66.
 ——— Mines, 80.
 ——— Mining Syndicate, 63-65.
 Perranporth, 63, 65.
 Perranzabuloe, 63-65.
 Petertavy, 54.
 Pettus, John, 56.
 Phillips, J. A., 12.
 Pits Mingle Mine, 58, 69.
 Plumley Mine, 55.
 Poorsland Level, 40, 41.
 Porlock, 31.
 ' Posts,' 8.
 Pounce, 47.
 Price, Rees, 61.
 Priddy, 28, 30.
 Prideaux Mine, 75.
 Proctor, E., 22.
 Prosper, Wheal, 53.
 Providence, 28.
 Psilomelane, 33, 41.
 Pyrites, arsenical, 49, 77, 78.
 ———, copper, 18, 49, 59, 62, 63,
 77, 78.
 ———, iron, 49, 51, 59, 62, 67, 78.

 Quarme, River, 40, 41.
 Quartz in lodes and veins, 33, 35, 37,
 43.

 Radstock, 28.
 ' Rakes,' 6.
 Raleigh's Cross Inn, 36, 37.
 ——— Mine, 33, 34, 37.
 Rangeworthy, 28.
 Rattery, 56.
 Redding (Reddle), 30, 31.
 Red House Mine, 30.
 ——— Vein, 10.
 Reed Mine, 55.
 Rejerrah, 65, 67.
 Reserves, 1, 2, 16, 35, 46, 47, 59, 62,
 65, 67.
 Restormel Mine, 56, 58-60, 75, 76.
 Retallack Mine, 65.
 Retew, 68.
 Retire and Wheal James Mine, 58,
 71, 72.
 Rigg, 11.
 Riley, E., 42, 43, 77.
 Rispey, 5.
 Roche, 58, 69, 71.
 Rodderup Fell, 12.
 Roebuck's Shaft, 66, 67.
 Roebuck, W. R., 60, 64, 66.
 Rogers's Lode, 42, 43.
 Roman Lode, 43.
 ——— Mine, 34, 36.
 ——— mining, 16, 30, 34.
 Rookhope, 4.
 Rose Mine, 80.

 Rosewarrick Mine, 71, 72.
 Rowantree Mines, 8, 11.
 Ruby Mine, 58, 59, 74.
 Ruddle, 30.
 Ruthers (Ruthvoes) Mine, 68.

 St. Austell, 58, 67, 74.
 ——— Mine, 79.
 St. Breock, 70.
 St. Clether, 58.
 St. Columb Major, 67.
 ——— Mines, 80.
 St. Day United Mine, 80.
 St. Enoder, 68.
 St. George's-in-Gordano, 28.
 St. John's Chapel, 8, 10, 11.
 St. Just, 58.
 St. Stephen-in-Brannel, 76.
 St. Stephen Mine, 79.
 Salcombe Mine, 53.
 Scar Limestone, 7, 11, 12, 14.
 Scottish Silvoid Co., Ltd., 50.
 Shapton Mine, 55.
 Sharkham Point, 46, 47, 52, 53.
 ——— Mine, 52.
 Shaugh Mine, 56.
 ——— Prior, 56.
 Sheepbridge Iron Co., 25.
 Shirwell Mines, 44.
 Shuttamoor Mine, 55.
 Siambr-wen, 25.
 Siderite, 58.
 Silver, horn, 65; native, 64, 65; ores,
 62, 66, 67.
 Simonsbath, 42, 43.
 Sir John's Vein, 12.
 Skirwith Fell, 14.
 Slants or Slopes, 35, 36.
 Slit Pasture, 11.
 Smallacombe Mine, 46, 48, 50.
 Smallcombe Bottom Mine, 34, 38.
 Smelting of ironstone, 29-31, 34, 36,
 44, 47.
 Smith, B., 21.
 ———, Mr., 34-36, 37.
 Smoky (Smallcombe) Bottom, 38.
 Smyth, W. W., 12, 27, 33, 34, 37,
 40-43, 45, 59, 62, 63.
 Snaigill, 11.
 Somerset, West, 31-45.
 ——— Minerals Syndicate, 34,
 35.
 South Devon Mine, 54.
 ——— United Mine, 54.
 South Exmouth Mine, 55.
 ——— Radworthy, 44.
 ——— Terras Mine, 58, 77.
 Spathic ore (Chalybite), Alston, 3,
 11, 12; Cornwall, 1-3, 58, 59,
 61-67, 70, 72, 74, 80; Devon
 (North), 1, 2, 31, 44, 45; Devon
 (South), 1-3, 48, 49, 54, 55; Isle
 of Man, 26, 27; Somerset, 1-3, 31,
 33, 34, 37-39, 41-43; Teesdale, 11;
 Weardale, 1-6.

- Specific gravity of ore, 34.
 Specular ore. *See* *Hæmatite*, mica-
 ceous.
 Speedwell Mine, 80.
 Sperries, Wheal, 58, 78.
 Spiegeleisen, 62.
 Spiller, J., 5.
 Spraycombe Mine, 44.
 Stack Mooar Mine, 27.
 Stanhope, 10.
 — Dene, 4.
 Stokes, A. H., 25, 26.
 Stowford Iron Mine, 44.
 Strahan, A., 15, 21.
 Sunnybrow Mine, 5, 10.
 Sunny Side, 10.

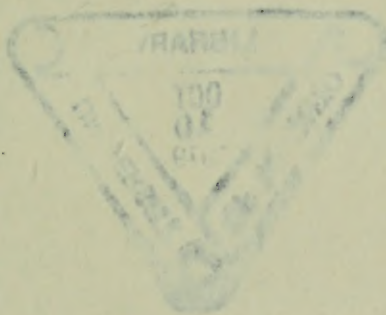
 Tamill, 58.
 Tate, N., 60.
 Teesdale, 11.
 Temple Cloud, 28, 30.
 Tennant's Shaft, 65.
 Tibbets, Mr., 34.
 Timwood, 34, 37.
 Tinstone, 51, 54, 77, 78.
 Tintagel, 58.
 Titanium, 16.
 Toldish, 67, 68.
 Tolgarriek, 77.
 Torbay Mines, 53.
 Tosh, E. G., 60.
 Tower Consols, 58, 69.
 Tow Law, 4.
 Treamble Mine, 57, 60, 61, 65.
 Trebarvah (Wheal Castle) Mine, 80.
 Trebarwith, 58.
 Trebisken Mine, 57, 64, 65.
 Treffry Mine, 58, 75.
 Trefresa Mine, 80.
 Tregawne Mine, 80.
 Tregelles Mine, 80.
 Tregonetha Mine, 80.
 Tregullian and Tretoil Mine, 80.
 Treliver Mine, 68.
 Trelow Mine, 80.
 Treluswell, 58, 80.
 Trerank Mine, 69.
 Tresibble Mine, 80.
 Trethurgy, 74.
 Treverbyn Mine, 58–60, 74.
 Trehwela and Benallack Mine, 80.
 Tripp Bottom, 36.
 Truro District, 78, 79.
 Trusham, 52.
 'Tuft,' 7.
 Tyddyn-y-cyll, 18.
 Tyne-Bottom Limestone, 6, 11.
 — Green, 12.
 — Vein, 12.
 Ty'n-llwyn, 21.
 Ty'n-y-caeau Mine, 15, 21.

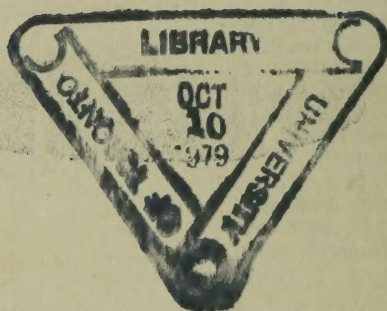
 Ugborough Mine, 56.
 Umber, 50, 54, 67, 68, 77, 78.
 Union Mine, 77.
 Upton Mine, 53.
 Uranium Mine, 77.

 Vale of Clwyd District, 19.
 — Fault, 19, 21.
 Vallance's Shaft, 67.
 Veins and Lodes: Barnstaple
 District, 44; Bracken Syke, 12;
 Brendon Hills, 33; Carr's, 8;
 Craig Green, 12; Crawley, 10;
 Cutcombe Barrow, 39; Dawson's,
 8, 10; Duchy Peru, 66; Eisen Hill,
 40; Exmoor District, 41–43; Far,
 8–10; Gaverigan, 68; Great, 77;
 Great Perran, 56, 58, 61–67;
 Groove Heads, 8, 10; Horse Edge,
 12, 13; Ilfracombe District, 44, 45;
 Leather Barrow, 38; Lowe's, 7–9;
 Madison's, 8, 10; Manor House, 7,
 12; North Molton District, 44;
 Park, 12; Park Grove, 13; Park
 Grove Sun, 13; Pawton, 58; Red,
 10; Restormel, 75, 76; Rogers's,
 42, 43; Roman, 43; Ruby, 74; Sir
 John's, 12; Trebellan, 64;
 Trebisken, 64; Tyne Green, 12;
 Uranium, 77; Wilson's, 8.
 Vitifer Mine, 47, 51, 54.

 Wad. *See* *Manganese*.
 Wadebridge, 58, 67, 70.
 Walker, A. O., 15, 21.
 Washford Valley, 34.
 Watchet, 31, 35.
 — Briquetting Syndicate, 35.
 Weardale, 7–11.
 — Steel, Coal and Coke Co.,
 Ltd., 5, 8, 10.
 Wear Head, 6, 8, 11.
 Wells (Somerset), 28, 30.
 West Level, 5.
 Weston-super-Mare, 28.
 Westbury, 28.
 West Downs Mine, 72.
 Westmorland, 12.
 West Rigg, 11.
 — Somerset Mineral Railway, 35,
 36, 39.
 'White ore.' *See* *Spathic ore*.
 Wick, 28, 30.
 Wilkinson, J. D., 23.
 Wilson's Vein, 8.
 Winford, 28–30.
 — *Hæmatite Co.*, 30.
 — *Iron Ore and Redding Co.*,
 Ltd., 30.
 Winsford, 33, 40.

- Winster, 26.
Withiel, 71.
——— Florey, 38.
——— Hill Mine, 34, 38.
Withielgoose, 72.
Withypool, 41, 42.
Wolborough Mine, 55.
Woodhouse, J. T., 60, 64, 73, 77.
Woodley Mine, 58, 72.
Woodward, H. B., 28.
Wookey, 28, 30.
Woolcombe, Little, Mine, 42, 43.
Woodlands Level, 13.
Wootton Courtney, 31.
Worth, R. N., 47.
Wright, H. J., 25.
Writing-sand, 46, 47, 51.
Wylam, 11.
Yatton, 28, 29.
Yealmpton Mine, 56.
Yeanon Mine, 31, 34, 36.
Ysceifiog, 18, 19.
Zinc ore, 15, 59, 62, 63, 66, 67, 77,
78.
-





Nos. 1 to 110, which have not yet been replaced by New Series Maps, are issued as whole sheets and quarter-sheets, hand-coloured, in either a "Solid" or a "Drift" edition, or in both. For Memoirs on Old Series Maps, see below.

SIX-INCH MAP (6 inches to the mile or 1 to 10560).

Parts of the Six Northern Counties were published on the six-inch scale prior to 1880. Large parts of the Coalfields of South Wales, North Staffordshire, Leicestershire, Derbyshire and Nottinghamshire, and the Mining District of Cornwall, have been published on that scale since 1903. Sheets published since 1903 can be procured with the Geological lines, uncoloured 1s. 6d. each quarter-sheet, or coloured, at the cost of colouring. Some are issued in both a "Drift" and "Solid" edition.

Six-inch maps which have not been published of areas geologically surveyed on this scale, are deposited in MS. in the Geological Survey Office, where they can be consulted, or copied if desired, at the cost of drawing and colouring.

HORIZONTAL SECTIONS.

1 to 140, 146 to 148.

VERTICAL SECTIONS.

1 to 90.

SHEET MEMOIRS OF OLD SERIES MAPS.

- 34 ... PARTS OF WILTS and GLOUCESTERSHIRE. By A. C. RAMSAY, W. T. AVELINE and E. HULL. 8d.
- 44 ... CHELTENHAM. By E. HULL. 2s. 6d.
- 45 ... BANBURY, WOODSTOCK, and BUCKINGHAM. By A. H. GREEN. 2s.
- 45 SW ... WOODSTOCK. By E. HULL. 1s.
- 47 ... N.W. ESSEX and N.E. HERTS. By W. WHITAKER, W. H. PENNING, W. H. DALTON, and F. J. BENNETT. 2s. 6d.
- 48 SW ... COLCHESTER. By W. H. DALTON. 1s. 6d.
- 48 NW, NE ... IPSWICH, HADELEIGH, and FELIXSTOWE. By W. WHITAKER, W. H. DALTON, and F. J. BENNETT. 2s.
- 48 SE ... EASTERN END of ESSEX (WALTON NAZE and HARWICH). By W. WHITAKER. 9d.
- 49 S, 50 SE ... ALDBOROUGH, &c. By W. H. DALTON. Edited, with additions, by W. WHITAKER. 1s.
- 49 N ... SOUTHWOLD. By W. WHITAKER. 2s. 6d.
- 50 NW ... DISS, EYE, &c. By F. J. BENNETT. 2s.
- 50 NE ... HALESWORTH and HARLESTON. By W. WHITAKER and W. H. DALTON. 1s.
- 50 SW ... STOWMARKET. By W. WHITAKER, F. J. BENNETT, and J. H. BLAKE. 2s.
- 51 NE ... PARTS of CAMBRIDGESHIRE and SUFFOLK. By W. WHITAKER (and Others). 2s.
- 51 SE ... BURY ST. EDMUNDS and NEWMARKET. By F. J. BENNETT, J. H. BLAKE, and W. WHITAKER. 1s.
- 53 SE ... PART of NORTHAMPTONSHIRE. By W. T. AVELINE and RICHARD TRENCH. 8d.
- 65 ... S.W. NORFOLK and N. CAMBS. By W. WHITAKER, S. B. J. SKETCHLEY, and A. J. JUKES-BROWNE. 3s.
- 66 SW ... ATTLEBOROUGH. By F. J. BENNETT. 1s. 6d.
- 67 NW ... E. DEREHAM. By J. H. BLAKE. 1s. 6d.
- 67 ... YARMOUTH and LOWESTOFT. By J. H. BLAKE. 2s.
- 68 NW, SW ... FAKENHAM, WELLS, &c. By H. B. WOODWARD. 2s.
- 68 E ... CROMER. By C. REID. 6s.
- 70 ... BORDERS of THE WASH. By W. WHITAKER and A. J. JUKES-BROWNE. 3s.
- 70 ... S.W. LINCOLNSHIRE, &c. By A. J. JUKES-BROWNE and W. H. DALTON. 4s.
- 71 NE ... NOTTINGHAM. By W. T. AVELINE. (2nd Ed.) 1s.
- 79 NW ... RHYL, ABERGELE, and COLWYN. By A. STRAHAN. (Notes by R. H. TIDDEMAN.) 1s. 6d.
- 79 SE ... FLINT, MOLD, and RUTHIN. By A. STRAHAN. (Parts by C. E. DE RANCE.) 4s. 6d.; Supplement 2d.
- 80 NW ... PRESCOT, LANCASHIRE. By E. HULL. (3rd Ed.) With additions by A. STRAHAN. 3s.
- 80 SW ... CHESTER. By A. STRAHAN. 2s.
- 81 NW, SW ... STOCKPORT, MACCLESFIELD, CONGLETON and LEEK. By E. HULL and A. H. GREEN. 4s.
- 82 NE ... PARTS of NOTTINGHAMSHIRE, YORKSHIRE, and DERBYSHIRE. (2nd Ed.) By W. T. AVELINE. 1s.
- 82 SE ... PARTS of NOTTINGHAMSHIRE and DERBYSHIRE. By W. T. AVELINE. (2nd Ed.) 6d.
- 83 ... LINCOLN. By W. A. E. USSHER, A. J. JUKES-BROWNE, and A. STRAHAN. 3s.
- 84 ... EAST LINCOLNSHIRE. By A. J. JUKES-BROWNE. 3s. 6d.
- 86 ... N. LINCOLNSHIRE and S. YORKSHIRE. By W. A. E. USSHER (and Others). 2s.
- 87 NW ... WAKEFIELD and PONTEFRAC. By A. H. GREEN. 6d.
- 87 SW ... BARNSLEY. By A. H. GREEN. 9d.
- 88 NE ... DEWSBURY, &c. By A. H. GREEN, J. R. DAKYNS, J. C. WARD, and R. RUSSELL. 6d.
- 88 SW ... OLDHAM. By E. HULL. 2s.
- 91 SW ... COUNTRY between BLACKPOOL, and FLEETWOOD. By C. E. DE RANCE. 6d.
- 92 SE ... BRADFORD and SKIPTON. By J. R. DAKYNS, C. FOX-STRANGWAYS, R. RUSSELL, and W. H. DALTON. 6d.
- 93 NE ... COUNTRY between YORK and MALTON. By C. FOX-STRANGWAYS. 1s. 6d.
- 93 SE, 94 SW ... COUNTRY between YORK and HULL. By J. R. DAKYNS, C. FOX-STRANGWAYS, and A. C. G. CAMERON. 1s. 6d.
- 94 NW ... DRIFFIELD. By J. R. DAKYNS and C. FOX-STRANGWAYS. 9d.
- 94 NE ... BRIDLINGTON BAY. By J. R. DAKYNS and C. FOX-STRANGWAYS. 1s.
- 95 NW ... WHITBY and SCARBOROUGH, country between. By C. FOX-STRANGWAYS and G. BARROW. (2nd Ed.) 2s. 6d.
- 104 SE ... SCARBOROUGH and FLAMBOROUGH HEAD. By C. FOX-STRANGWAYS. (2nd Ed.) 4s. 6d.
- 96 NE ... ESKDALE, ROSEDALE, &c. By C. FOX-STRANGWAYS, C. REID, and G. BARROW. 1s. 6d.
- 96 NW, SW ... NORTHALLERTON and THIRSK. By C. FOX-STRANGWAYS, A. C. G. CAMERON, and G. BARROW. 1s. 6d.
- 96 SE ... NEW MALTON, PICKERING, and HELMSLEY. By C. FOX-STRANGWAYS. 1s.
- 97 NW ... MALLERSTANG. By J. R. DAKYNS, R. H. TIDDEMAN (and Others). 3s. 6d.
- 97 SW ... INGLEDOROUGH. By J. R. DAKYNS, R. H. TIDDEMAN, W. GUNN, and A. STRAHAN. 2s.
- 98 NE ... KENDAL. By W. T. AVELINE and T. McK. HUGHES. 2nd Ed. by A. STRAHAN. 2s.
- 102 SW ... APPELEY, ULLSWATER, &c. By J. R. DAKYNS, R. H. TIDDEMAN, and J. G. GOODCHILD. 1s. 6d.
- 104 SW, SE ... NORTH CLEVELAND. By G. BARROW. 1s. 6d.
- 107 ... CARLISLE. By T. V. HOLMES. 1s. 3d.
- 108 NE ... CHEVIOT HILLS. By C. T. CLOUGH. 1s. 6d.
- 108 SW ... FLASHETTS and KIELDER. By C. T. CLOUGH. 1s.
- 108 SE ... OTTERBURN and ELSDON. By HUGH MILLER. 2s. 6d.
- 110 NW ... NORHAM and TWEEDMOUTH. By W. GUNN. 6d.
- 110 NE ... COAST SOUTH of BERWICK-ON-TWEED. By W. GUNN. 9d.
- 110 SW ... WOOLER and COLDSTREAM. By W. GUNN and C. T. CLOUGH. 1s. 6d.
- 110 SE ... BELFORD, HOLY ID and FARNE ISLANDS. By W. GUNN. 2s. 6d.

GENERAL MEMOIRS.

- SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY for 1897 to 1915. Each 1s.
 SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY for 1916. 1s. 6d.
 SUMMARY OF PROGRESS OF THE GEOLOGICAL SURVEY for 1917. 2s.
 PLEOCENE DEPOSITS OF BRITAIN. By C. REID. 5s. 6d.
 CRETACEOUS ROCKS OF BRITAIN. Vol. I. GAULT AND UPPER GREENSAND OF ENGLAND. 6s.
 Vol. II. LOWER AND MIDDLE CHALK. 10s. Vol. III. UPPER CHALK. 10s. By A. J. JUKES-BROWNE and W. HILL.
 JURASSIC ROCKS OF BRITAIN. Vol. I. YORKSHIRE. 8s. 6d. Vol. II. YORKSHIRE, POSSIL, 12s. By C. FOX-STRANGWAYS. Vol. III. LIAS OF ENGLAND (Yorkshire excepted). 7s. 6d. By H. B. WOODWARD. Vol. IV. The Lower Oolitic Rocks of England. 10s. By H. B. WOODWARD. Vol. V. The Middle and Upper Oolitic Rocks of England. 7s. 6d. By H. B. WOODWARD.
 THICKNESSES OF STRATA IN THE COUNTIES OF ENGLAND AND WALES, EXCLUSIVE OF ROCKS OLDER THAN THE PERMIAN. 4s. 6d.

DISTRICT MEMOIRS.

- MEMOIRS of the GEOLOGICAL SURVEY OF GREAT BRITAIN. Vol. I. ESSAYS by SIR H. T. DE LA BECHE and Others. 21s. Vol. II. Part I, MALVERN HILLS. By J. PHILLIPS. 21s. Part 2, ESSAYS. 21s. Vol. III. N. WALES. By SIR A. C. RAMSAY. App., by J. W. SALTER and R. ETHERIDGE. 2nd Ed. 21s.
 GUIDE TO GEOLOGICAL MODEL OF THE ASSYNT MOUNTAINS. By B. N. PEACH and J. HORNE. Price 1d.
 CAMBRIDGE. By W. H. PENNING and A. J. JUKES-BROWNE. 4s. 6d.
 CORNWALL, DEVON, AND WEST SOMERSET. INDEX to DE LA BECHE'S Report on. By C. REID. 1s.
 DERBYSHIRE, NORTH. By A. H. GREEN, C. LE NEVE FOSTER and J. R. DAKYNS. 2nd Ed. By A. H. GREEN and A. STRAHAN. 5s. 6d.
 FALMOUTH AND TRURO AND MINING DISTRICT OF CAMBORNE AND REDRUTH. By J. B. HILL and D. A. MACALISTER. 7s. 6d.
 FENLAND. By S. B. J. SKETCHLY. 36s. 6d.
 HOLDERNESSE. By C. REID. 4s.
 ISLE OF MAN. By G. W. LAMPLUGH. 12s.
 TERTIARY FLUVIO-MARINE FORMATION of the ISLE OF WIGHT. By EDWARD FORBES. 5s.
 ISLE OF WIGHT. By H. W. BRISTOW. New Ed. By C. REID and A. STRAHAN. 8s. 6d.
 GUIDE TO GEOLOGICAL MODEL OF INGLEDOROUGH DISTRICT. By A. STRAHAN. 4d.
 ISLE OF PURBECK AND WEYMOUTH. By A. STRAHAN. 10s. 6d.
 GUIDE TO GEOLOGICAL MODEL OF ISLE OF PURBECK. By A. STRAHAN. 6d.
 KENT, ON THE MESOZOIC ROCKS IN SOME OF THE COAL EXPLORATIONS IN. By G. W. LAMPLUGH and F. L. KITCHIN. 3s. 6d.
 LAKE DISTRICT, NORTHERN PART OF. By J. C. WARD. 9s.
 LANCASHIRE, SUPERFICIAL DEPOSITS OF SOUTH WEST. By C. E. DE RANCE. 10s. 6d.
 LONDON AND PART OF THE THAMES VALLEY. By W. WHITAKER. Vol. I., 6s. Vol. II., 5s.
 LYMINGTON AND PORTSMOUTH. By H. J. OSBORNE WHITE. 1s. 6d.
 MIDLAND COUNTIES, TRIASSIC AND PERMIAN ROCKS of the. By E. HULL. 5s.
 NORFOLK AND SUFFOLK, VERTEBRATA of the FOREST BED SERIES of. By E. T. NEWTON. 7s. 6d.
 NORWICH. By H. B. WOODWARD. 7s.
 RUTLAND, &c. By J. W. JUDD. 12s. 6d.

Coal Fields:—

- YORKSHIRE COALFIELD. By A. H. GREEN, R. RUSSELL (and Others). 42s.
 YORKSHIRE AND NOTTINGHAMSHIRE, CONCEALED COALFIELD of. By W. GIBSON. 1s. 6d.
 EAST SOMERSET AND BRISTOL COALFIELDS. By H. B. WOODWARD. 18s.
 WARWICKSHIRE COALFIELD. By H. H. HOWELL. 1s. 6d.
 LEICESTERSHIRE AND SOUTH DERBYSHIRE COALFIELD. By C. FOX-STRANGWAYS. 6s.
 NORTH STAFFORDSHIRE COALFIELDS. By W. GIBSON (and Others). 6s.
 SOUTH WALES, Coals of. By A. STRAHAN and W. POLLARD. 2nd Ed. 2s.
 SOUTH WALES. See under New Series Maps and Memoirs.

Sanitation and Water Supply:—

- SOILS AND SUBSOILS from a SANITARY POINT OF VIEW. By H. B. WOODWARD. 2nd Ed. 1s. 6d.
 NOTES ON SOURCES of TEMPORARY WATER SUPPLY in the SOUTH of ENGLAND and NEIGHBOURING PARTS of the CONTINENT. 2d.

WATER SUPPLY from underground sources of:—

BEDFORDSHIRE and NORTHAMPTON-	s. d.	NOTTINGHAMSHIRE	s. d.
SHIRE	4 6	OXFORDSHIRE	5 0
BERKSHIRE	3 0	SUFFOLK	2 3
ESSEX	15 0	SURREY	3 6
HAMPSHIRE (including Isle of Wight)	5 0	SUSSEX	7 0
KENT	8 6	SUSSEX (Supplement)	3 6
LINCOLNSHIRE	4 6	SUSSEX (Supplement)	2 0
LONDON WELLS	4 6	YORKSHIRE, EAST RIDING OF	3 6

- RECORDS OF LONDON WELLS. By G. BARROW and L. J. WILLS. 4s. 6d.

Museum Catalogues:—

- HANDBOOK TO BRITISH MINERALS. By F. W. RUDLER (and Others). 1s.
 GUIDE TO THE COLLECTION of GEMSTONES in the MUSEUM of PRACTICAL GEOLOGY. By W. F. P. MCINTOCK. 9d.
 HANDBOOK TO THE COLLECTION of KAOLIN, CHINA-CLAY AND CHINA-STONE in the MUSEUM of PRACTICAL GEOLOGY. By J. ALLEN HOWE. 3s. 6d.

Special Reports on the Mineral Resources of Great Britain:—

- VOL. 1. TUNGSTEN AND MANGANESE ORES. 2nd Ed. 1s.
 VOL. 2. BARYTES AND WITHERITE. 2nd Ed. 2s.
 VOL. 3. GYPSUM, ANHYDRITE, CELESTINE AND STRONTIANITE. 2nd Ed. 2s.
 VOL. 4. FLUORSPAR. 2nd Ed. 9d.
 VOL. 5. POTASH-FELSPAR, PHOSPHATE of LIME, ALUM SHALES, PLUMBAGO OR GRAPHITE, MOLYBDENITE, CHROMITE, TALC and STEATITE (SOAPSTONE, SOAP-ROCK and POTSTONE), DIATOMITE. 2nd Ed. 1s.
 VOL. 6. REFRACTORY MATERIALS: GANISTER AND SILICA-ROCK, SAND FOR OPEN-HEARTH STEEL FURNACES, DOLOMITE. RESOURCES and GEOLOGY. 7s. 6d.
 VOL. 7. LIGNITES, JETS, KIMMERIDGE OIL-SHALE, MINERAL OIL, CANNEL COALS, NATURAL GAS. Part I.—(ENGLAND AND WALES). 2s. 6d.
 VOL. 8. IRON ORES. Hematites of West Cumberland, Lancashire and the Lake District.
 VOL. 9. IRON ORES (cont.): SUNDRY UNBEDDED ORES of Durham, East Cumberland, North Wales, Derbyshire, Isle of Man, Bristol District and Somerset, Devon and Cornwall.
 VOL. 10. IRON ORES (cont.): The Hematites of the Forest of Dean and South Wales.